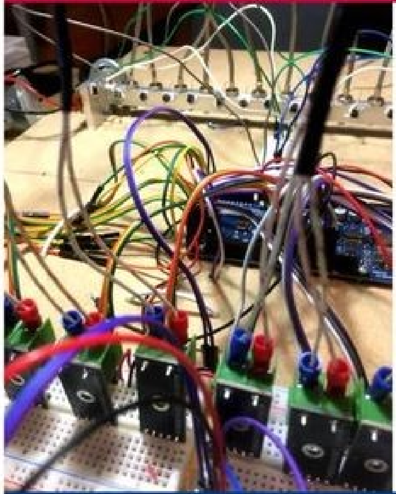
Control de calor como ondas



Semblanza

El Dr. Jesús Manzanares estudia la propagación de ondas en medios periódicos. Desarrolló su doctorado en la Universidad de Montepellier II en donde estudio la difracción óptica de ópalos haciendo simulaciones computacionales y cálculos teóricos.

Hoy en día hace investigación teórica en diferentes temas tales como cristales fotónicos, termocristales, cristales de ondas térmicas, cristales fotónicos, vibraciones en placas, etc. En el último año, ha efectuado experimentos con Arduino destinados a comprender los fenómenos de interferencia en la propagación de ondas de calor.

Martes 23 de noviembre de 2021. 12:00 pm. (UTC-6)

Transmisión por zoom https://us06web.zoom.us/j/87857555123?

ID: 878 5755 5123 | Código: 54548

Resumen

¿Puede el calor controlarse como una onda?, ¿Existirá la forma de aprovechar la energía que se desperdicia en calor? Recientemente, los investigadores han realizados avances para tener un mejor entendimiento teórico y experimental de la manera en como el calor se transporta en nanomateriales. Vamos a describir el mecanismo de fenómenos de interferencia que pueden permitir moldear el flujo de calor de manera novedosa.

MCTP

ICTP

CONACYT

UNESCO

Control de calor como ondas

Dr. Jesus Manzanares Martinez
Departamento de Investigacion en Fisica
Universidad de Sonora

Pueden encontrar la presentacion en http://manza.space


https://www.eurekalert.org/news-releases/804559

EurekAlert! AAAS

HOME NEWS RELEASES MULTIMEDIA MEETINGS

NEWS RELEASE 23-JUN-2015

Can heat be controlled as waves?

Peer-Reviewed Publication

GEORGIA INSTITUTE OF TECHNOLOGY

Print Email App

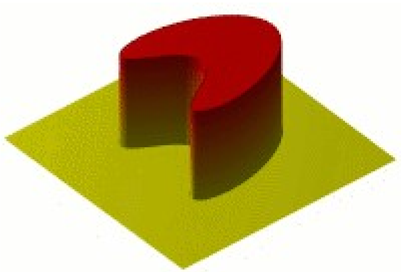
A growing interest in thermoelectric materials -- which convert waste heat to electricity -- and pressure to improve heat transfer from increasingly powerful microelectronic devices have led to improved theoretical and experimental understanding of how heat is transported through nanometer-scale materials.

Recent research has focused on the possibility of using interference effects in phonon waves to control heat transport in

https://www.eurekalert.org/news-releases/804559

?Puede el calor ser controlado como una onda?

$$\frac{\partial u}{\partial t} = \Delta u.$$



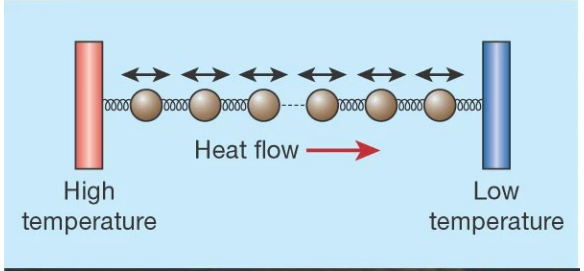
La ecuacion de calor usualmente tiene soluciones en donde el calor se “desparrama”

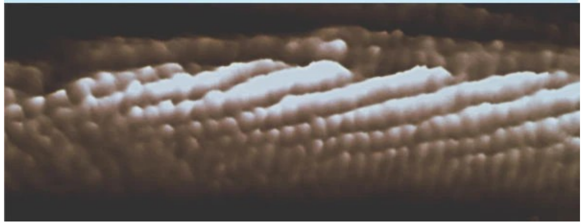
Gran parte de la energia en los dispositivos electronicos se pierde como calor de joule.

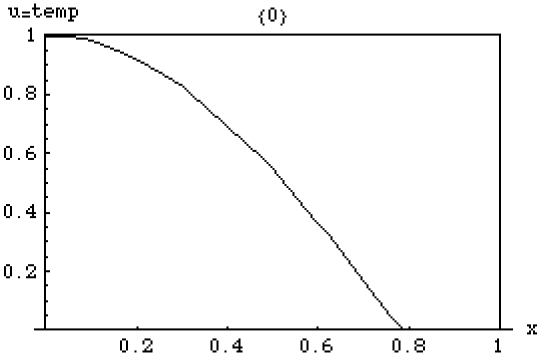
El calor de Joule

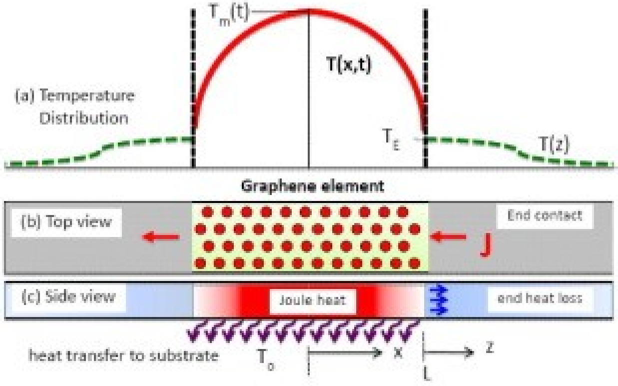
Se conoce como efecto Joule al fenómeno irreversible por el cual si en un conductor circula corriente eléctrica, parte de la energía cinética de los electrones se transforma en calor debido a los constantes choques que sufren con los átomos del material conductor por el que circulan, elevando la temperatura del mismo. El movimiento de los electrones en un alambre es desordenado; esto provoca continuas colisiones con los núcleos atómicos y como consecuencia, una pérdida de energía cinética y un aumento de la temperatura en el propio alambre.

El nombre es en honor a su descubridor, el físico británico James Prescott Joule.





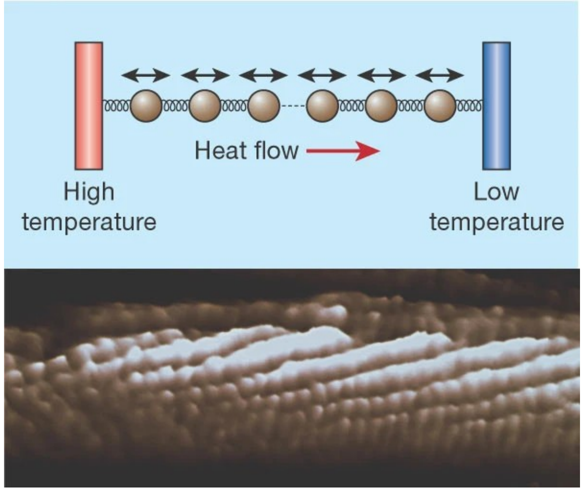


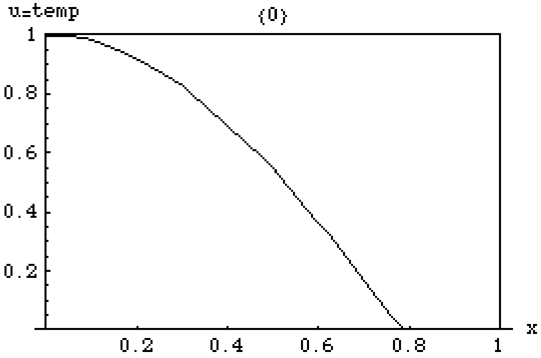


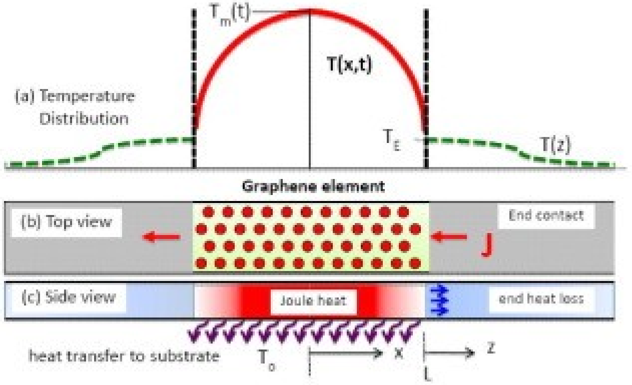
What is Joule Heating?

Joule heating is the physical effect by which the pass of current through an electrical conductor produces thermal energy. This thermal energy is then evidenced through a rise in the conductor material temperature, thus the term “heating”. One can see Joule heating as a transformation between “electrical energy” and “thermal energy”, following the energy conservation principle.

Las perdidas de energia por calor son inevitables?







Baby H. P.

Juan José Arreola

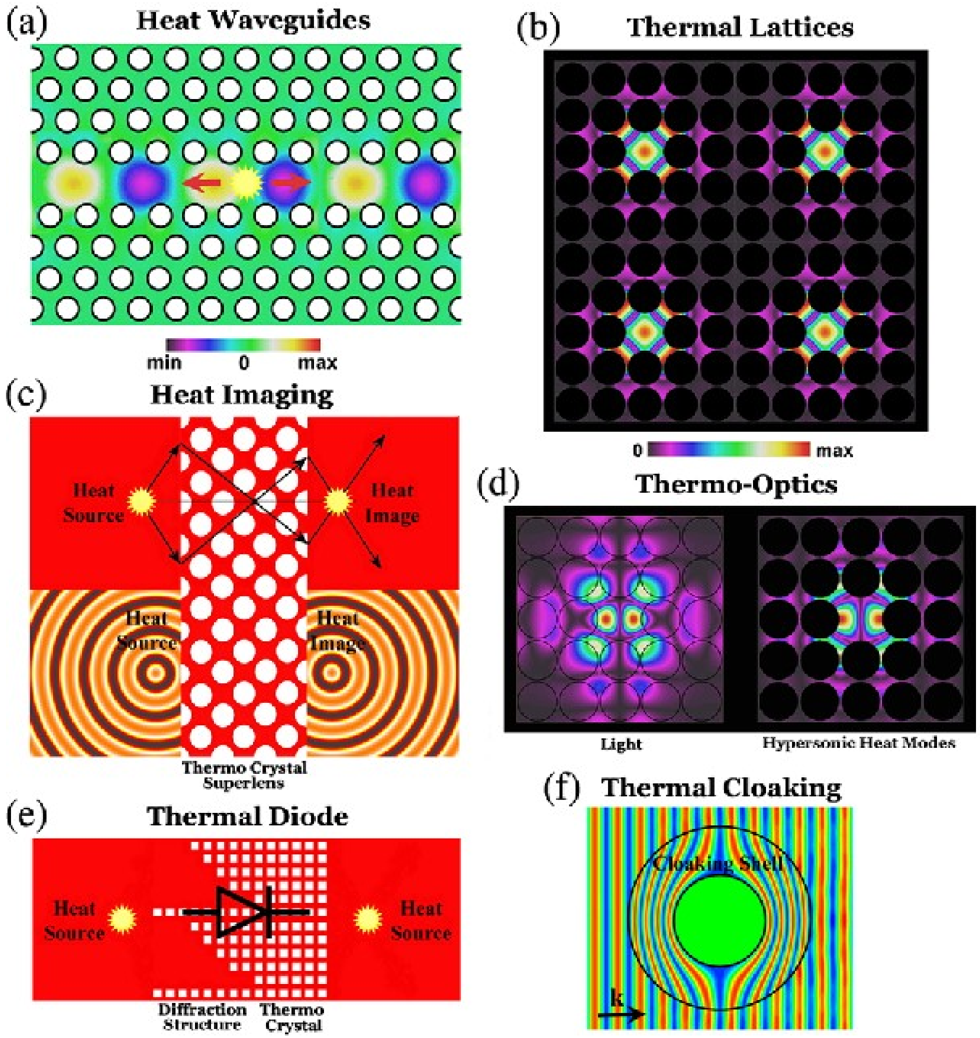
Señora ama de casa: convierta usted en fuerza motriz la vitalidad de sus niños. Ya tenemos a la venta el maravilloso Baby H.P., un aparato que está llamado a revolucionar la economía hogareña.

El Baby H.P. es una estructura de metal muy resistente y ligera que se adapta con perfección al delicado cuerpo infantil, mediante cómodos cinturones, pulseras, anillos, y broches. Las ramificaciones de este esqueleto suplementario recogen cada uno de los movimientos del niño, haciéndolos converger en una botellita de Leyden que puede colocarse en la espalda o en el pecho, según necesidad. Una aguja indicadora señala el momento en que la botella está llena. Entonces usted, señora, debe desprenderla y enchufarla en un depósito especial, para que se descargue automáticamente. Este depósito puede colocarse en cualquier rincón de la casa, y representa una preciosa alcancía de electricidad disponible en todo momento para fines de alumbrado y calefacción, así como para impulsar alguno de los innumerables artefactos que invaden ahora, y para siempre, los hogares.

De hoy en adelante usted verá con otros ojos el agobiante ajetreo de sus hijos. Y ni siquiera perderá la paciencia ante una rabieta convulsiva, pensando que es fuente generosa de energía. El pataleo de un niño de pecho durante las veinticuatro horas del día se transforma, gracias al Baby H.P., en unos útiles segundos de tromba licuadora, o en quince minutos de música radiofónica.

Las familias numerosas pueden satisfacer todas sus demandas de electricidad instalando un Baby H.P. en cada uno de sus vástagos, y hasta realizar un pequeño y lucrativo negocio, trasmitiendo a los vecinos un poco de la energía sobrante. En los grandes edificios de departamentos pueden suplirse satisfactoriamente las fallas del servicio público, enlazando todos los depósitos familiares.

El Baby H.P. no causa ningún trastorno físico ni psíquico en los niños, porque no cohíbe ni trastorna sus movimientos. Por el contrario, algunos médicos opinan



Narrow low-frequency spectrum and heat management by thermocrystals,

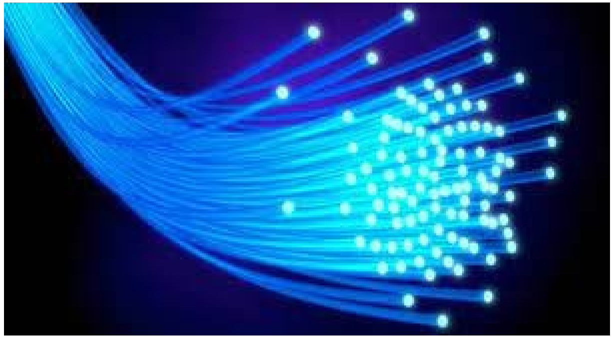
Martin Maldovan, Physical review letters, 2013, 025902

Revoluciones industriales

Revolucion 0: La agricultura. Fue posible por el control del flujo de agua.

Primera revolucion. Fue posible por el control del vapor

segunda revolucion. Fue posible por el control de electricidad y la luz



Recent research has focused on the possibility of using interference effects in phonon waves to control heat transport in materials.

Wave interference is already used to control electronic, photonic and acoustic devices.

If a similar approach can be used in thermal transport, that could facilitate development of more efficient thermoelectric and nanoelectronic devices, improved thermal barrier coatings, and new materials with ultralow thermal conductivity.


NEWS RELEASE 23-JUN-2015

Can heat be controlled as waves?

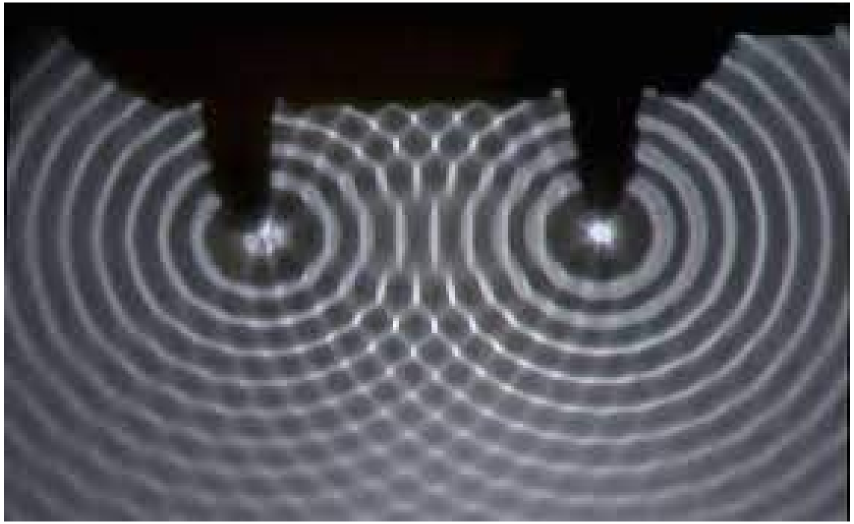
Peer-Reviewed Publication

GEORGIA INSTITUTE OF TECHNOLOGY

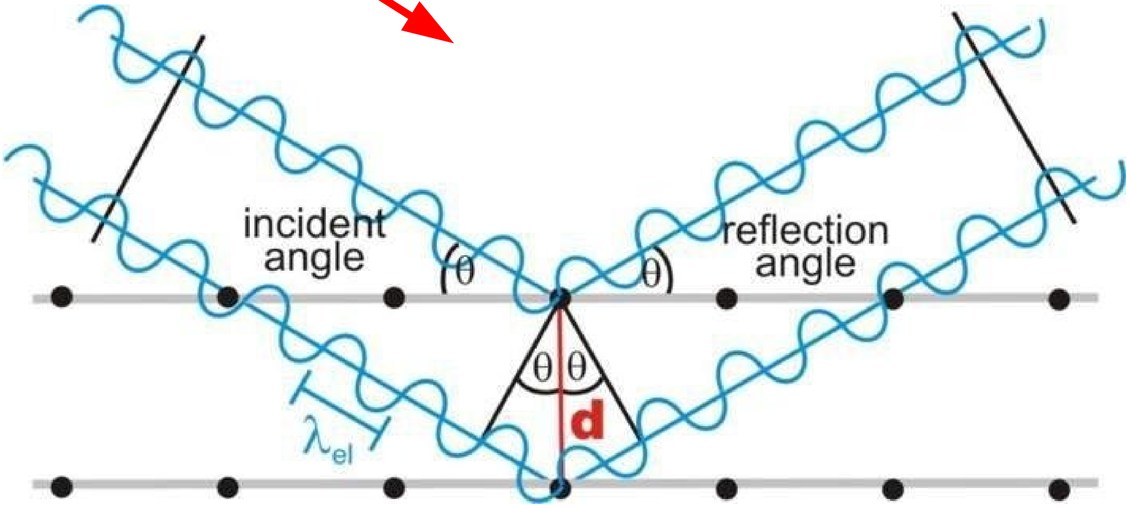
Print Email App

A growing interest in thermoelectric materials -- which convert waste heat to electricity -- and pressure to improve heat transfer from increasingly powerful microelectronic devices have led to improved theoretical and experimental understanding of how heat is transported through nanometer-scale materials.

Recent research has focused on the possibility of using interference effects in phonon waves to control heat transport in



interferencia

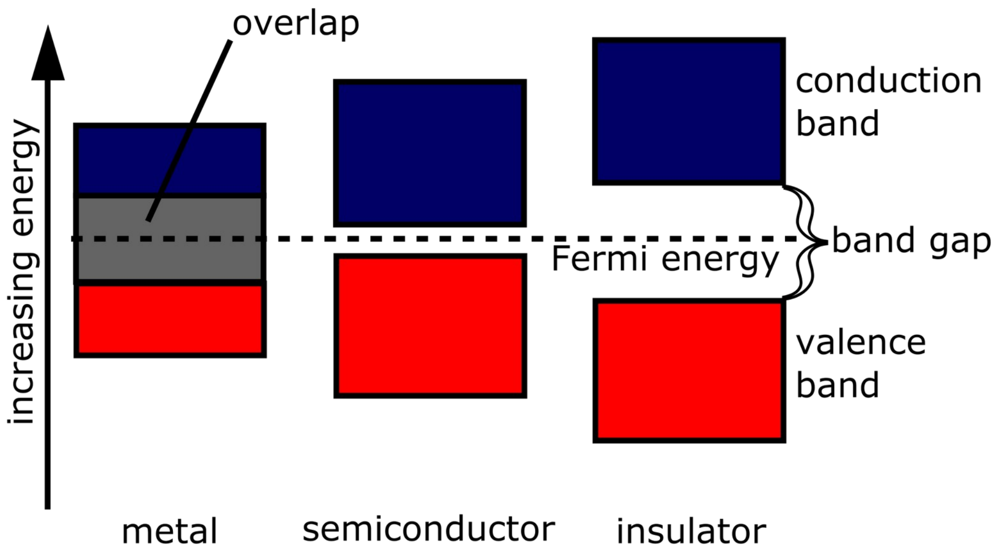


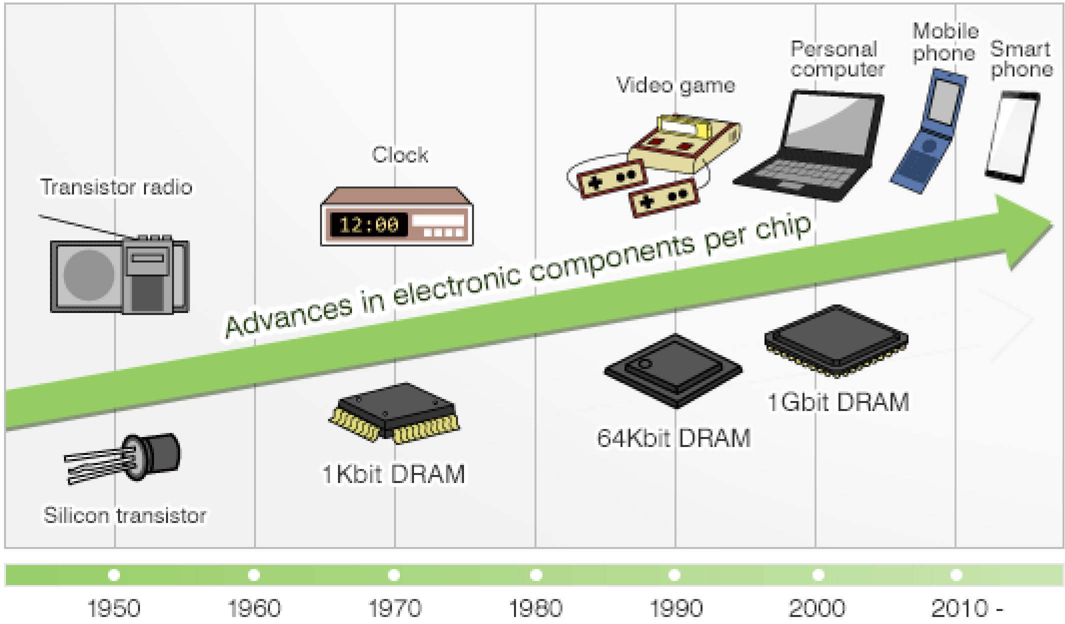
Difraccion de rayos X: los electrones interfieren co una red cristalina

Semiconductor

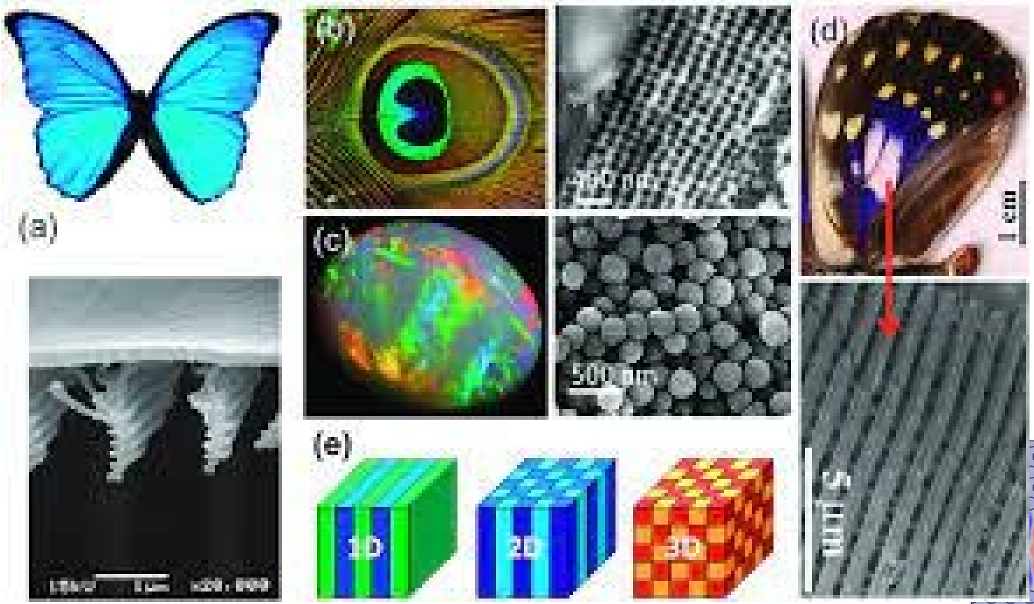
A semiconductor material has an electrical conductivity value falling between that of a conductor, such as metallic copper, and an insulator, such as glass. Its resistivity falls as its temperature rises; metals behave in the opposite way. Its conducting properties may be altered in useful ways by introducing impurities ("doping") into the crystal structure. When two differently doped regions exist in the same crystal, a semiconductor junction is created. The behavior of charge carriers, which include electrons, ions, and electron holes, at these junctions is the basis of diodes, transistors, and most modern electronics.

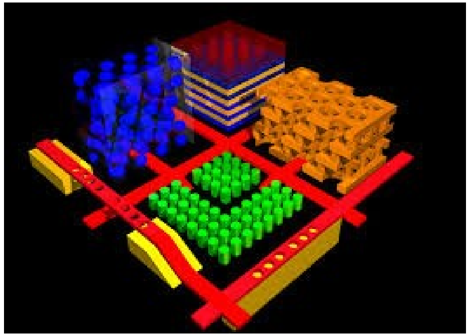
https://en.wikipedia.org/wiki/Semiconductor

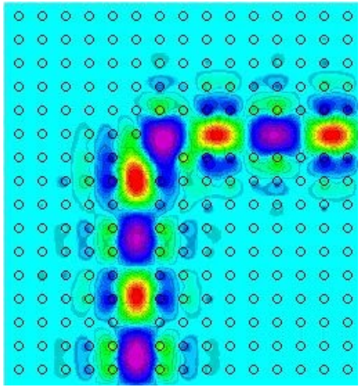


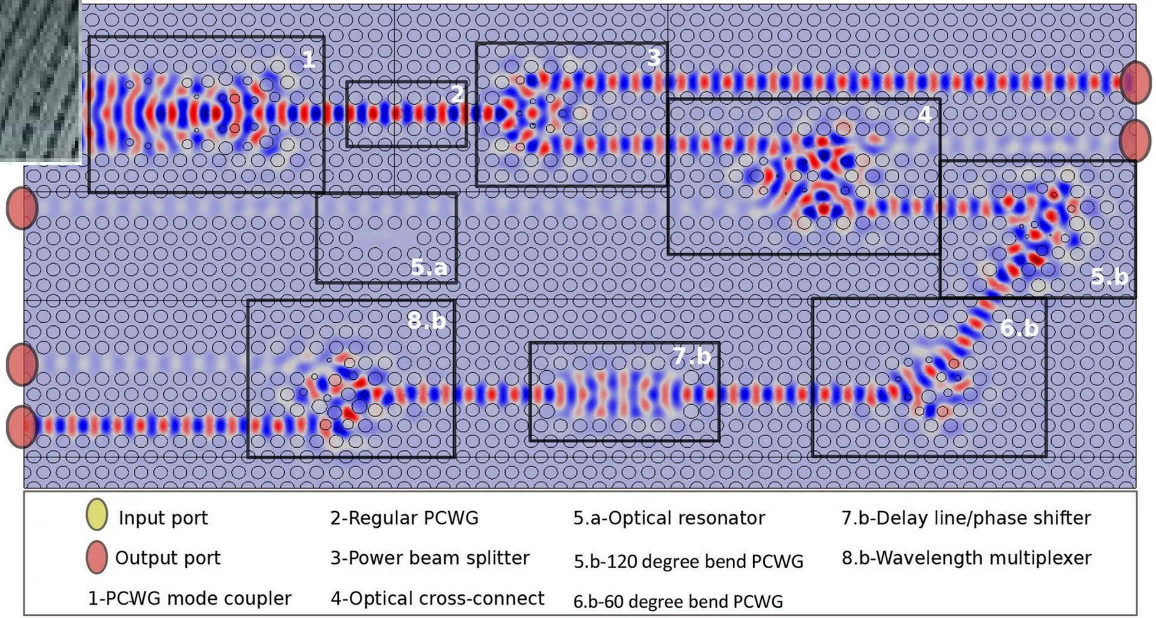


A photonic crystal is a periodic optical nanostructure that affects the propagation of light in the same way that the structure of natural crystals gives rise to X-ray diffraction and that the atomic lattices (crystal structure) of semiconductors affect their conductivity of electrons. Photonic crystals occur in nature in the form of structural coloration and animal reflectors, and, as artificially produced, promise to be useful in a range of applications.

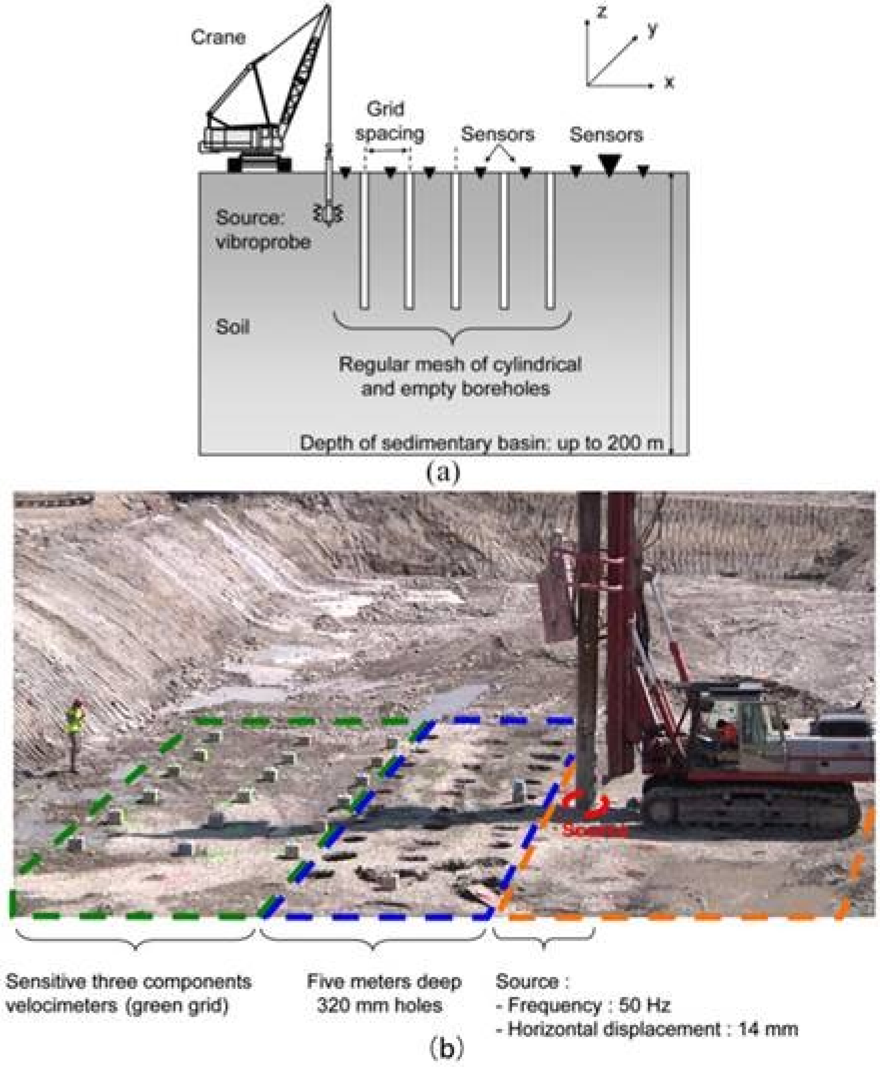


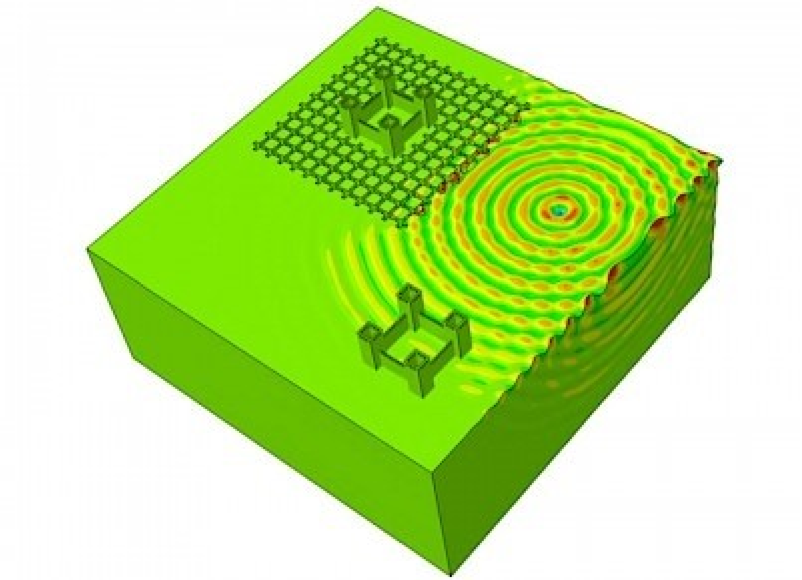






An phononic crystal, is a material designed to control, direct, and manipulate sound waves or phonons in gases, liquids, and solids (crystal lattices). Sound wave control is accomplished through manipulating parameters such as the bulk modulus β, density ρ, and chirality. They can be engineered to either transmit, or trap and amplify sound waves at certain frequencies. In the latter case, the material is an acoustic resonator.





Recent research has focused on the possibility of using interference effects in phonon waves to control heat transport in materials. Wave interference is already used to control electronic, photonic and acoustic devices. If a similar approach can be used in thermal transport, that could facilitate development of more efficient thermoelectric and nanoelectronic devices, improved thermal barrier coatings, and new materials with ultralow thermal conductivity

"If you can make heat behave as a wave and have interference while controlling how far it moves, you could basically control all the properties behind heat transport," said Martin Maldovan, an assistant professor in the School of Chemical and Biomolecular Engineering and School of Physics at the Georgia Institute of Technology, and the paper's author. "This would be a completely new way to understand and manipulate heat."


NEWS RELEASE 23-JUN-2015

Can heat be controlled as waves?

Peer-Reviewed Publication

GEORGIA INSTITUTE OF TECHNOLOGY

Print Email App

A growing interest in thermoelectric materials -- which convert waste heat to electricity -- and pressure to improve heat transfer from increasingly powerful microelectronic devices have led to

https://www.eurekalert.org/news-releases/804559

"Considering the remarkable success achieved when using electronic, photonic and phononic wave interference to manipulate electrons, light and sound waves, it is certainly valuable to extend these theories to thermal vibrations, thereby creating a fundamentally new approach for manipulating heat flow," Maldovan wrote in the paper.

"These new wave phenomena can be used to create materials with low thermal conductivity," said Maldovan. "We are trying to create a thermal bandgap, but that is not so easy to do."

The search for thermal phononic wave materials will focus on semiconductors much like those used in microelectronics, Maldovan said. But while the silicon used in microelectronics had a natural bandgap, scientists had to create a band gap in photonics and acoustic materials, and the same will be true for thermal materials. Likely materials include silicon-germanium, gallium and aluminum arsenide and certain oxide superlattices.

"It's now a very cool thing to understand heat," he said.

doi:10.1038/nature12608

Sound and heat revolutions in phononics

Martin Maldovan[1,2]

The phonon is the physical particle representing mechanical vibration and is responsible for the transmission of everyday sound and heat. Understanding and controlling the phononic properties of materials provides opportunities to thermally insulate buildings, reduce environmental noise, transform waste heat into electricity and develop earthquake protection. Here I review recent progress and the development of new ideas and devices that make use of phononic properties to control both sound and heat. Advances in sonic and thermal diodes, optomechanical crystals, acoustic and thermal cloaking, hypersonic phononic crystals, thermoelectrics, and thermocrystals herald the next technological revolution in phononics.

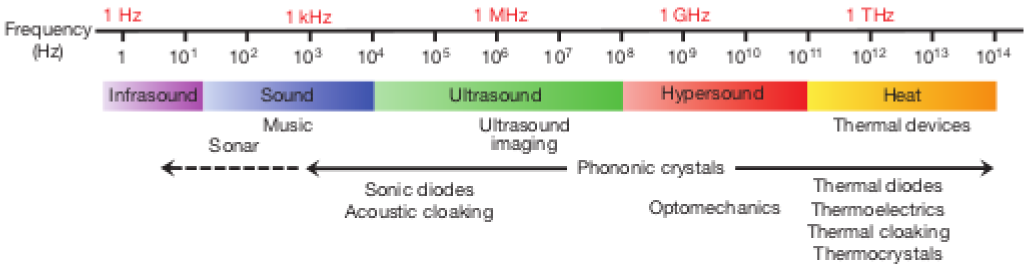


Figure 1 | The phononic spectrum.

Maldovan, Martin (2013). Sound and heat revolutions in phononics. Nature, 503(7475), 209–217. doi:10.1038/nature12608

In recent decades, major technological revolutions have transformed our society and daily lives. Their remarkable innovations have been based primarily on our improved ability to manipulate two particles: electrons and photons. In particular, the control of electrons in semiconductor materials has generated fundamental changes, with laptops, mobile telephones and digital cameras now products that seem always to have existed. Analogously, the development of materials and devices with which to control photons has generated major changes in society, such as wireless communication and the use of optical fibres and microwaves. The successful management of the electromagnetic spectrum is

Besides electrons and photons, another everyday particle is the phonon, which is responsible for the transmission of sound and heat. Given the many applications of our remarkable success in managing electrons and photons, it would be valuable to achieve a similar degree of control over the particle that accounts for both sound and heat (Fig. 1). Although some sonic and thermal devices and materials, such as medical ultrasound imaging machines and thermal insulation materials, are well known, further applications for phononic devices are developing fast, from thin acoustic metamaterials that can soundproof rooms to enhanced thermoelectric devices that can use our bodies' waste heat to power portable electronic devices.

Maldovan, Martin (2013). Sound and heat revolutions in phononics. Nature, 503(7475), 209–217. doi:10.1038/nature12608

RESEARCH REVIEW

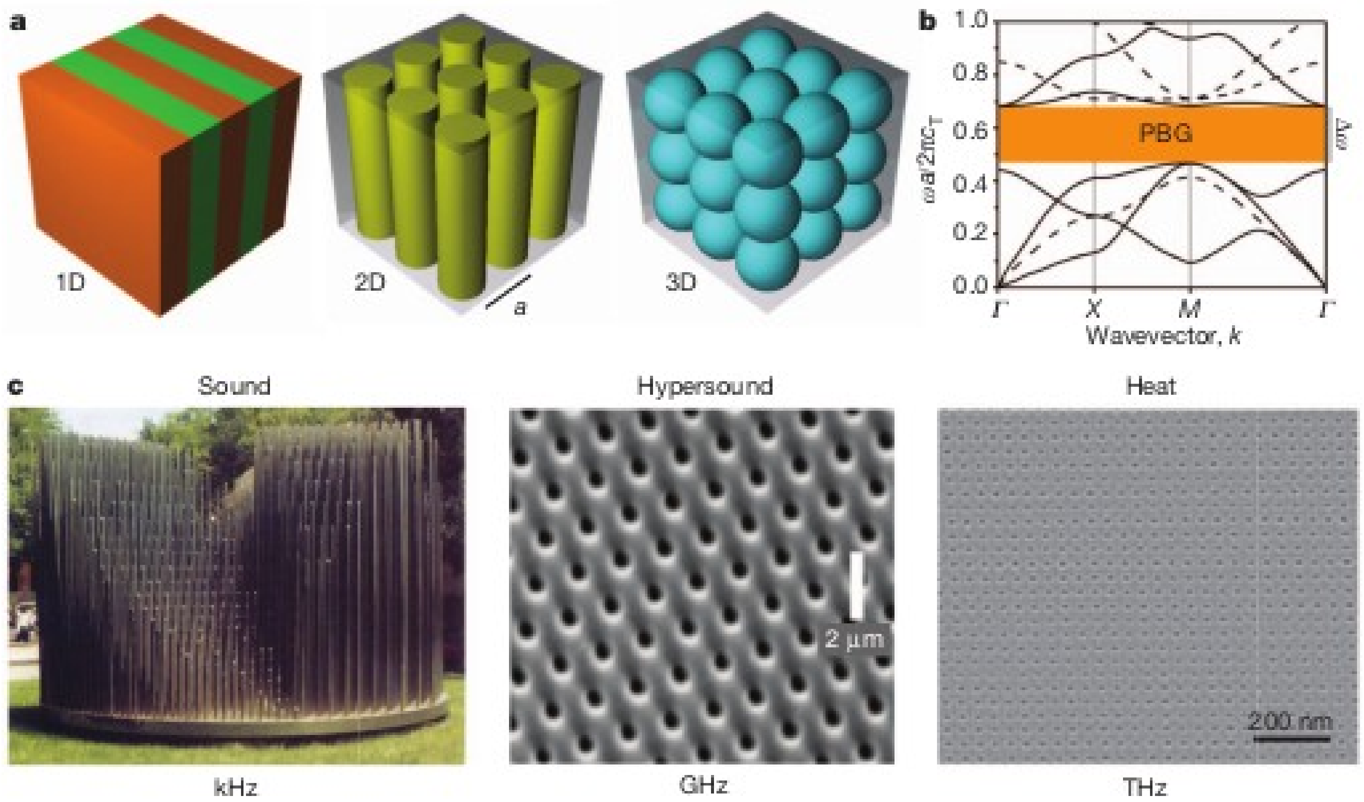


Figure 2 | Phononic crystals. **a**, 1D, 2D and 3D phononic crystals made of two different elastic materials arranged periodically. Different colours represent materials with different elastic properties. **b**, An example of a phononic band diagram $\omega = \omega(k)$ for a two-dimensional phononic crystal, in which non-dimensional frequencies $\omega a/2\pi c_T$ (with c_T a transverse velocity) are plotted versus the wavevector k along the Γ–X–M–Γ path in the square Brillouin zone. The range of forbidden frequencies, or PBG, is shown in orange. **c**, 2D phononic crystals with periodicities a in the centimetre range (left), the micrometre range (middle) and the tens-of-nanometres range (right) can be used to control sound, hypersound and heat, respectively. Images are taken from fig. 1 of ref. 3 (left image, with permission), fig. 1a of ref. 8 (middle image) and fig. 1b of ref. 11 (right image, with permission).

Maldovan, Martin (2013). Sound and heat revolutions in phononics. Nature, 503(7475), 209–217. doi:10.1038/nature12608

APPLIED PHYSICS LETTERS **95**, 241909 (2009)

Observation of hypersonic phononic crystal effects in porous silicon superlattices

L. C. Parsons and G. T. Andrews[a)]
Department of Physics and Physical Oceanography, Memorial University, St. John's, Newfoundland A1B 3X7, Canada

(Received 30 September 2009; accepted 27 November 2009; published online 18 December 2009)

Brillouin light scattering experiments were carried out on porous silicon superlattices with modulation wavelengths in the range 37–167 nm. Phonon frequencies deduced from the Brillouin spectra show good agreement with those obtained from an elastic continuum model for a system with one-dimensional periodicity. Evidence for the existence of a hypersonic phononic bandgap and zone-folded longitudinal acoustic phonons is reported.
[doi:10.1063/1.3275742]

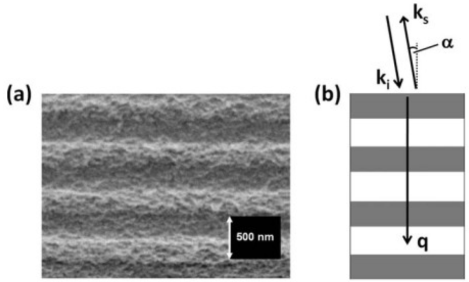
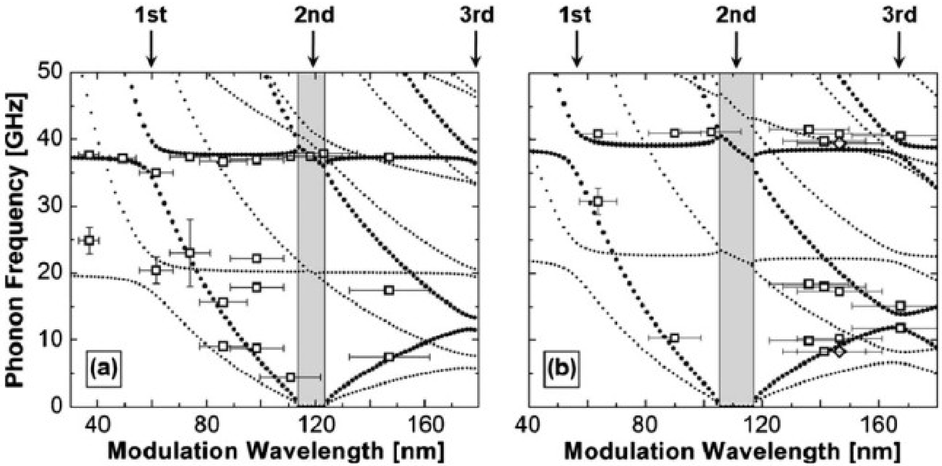


FIG. 1. (a) Cross-sectional scanning electron micrograph of a $D=500$ nm SL. The bright (dark) regions correspond to layers with a porosity of 0.56 (0.46). (b) Scattering geometry. The wavevectors of the probed phonon and the incident (scattered) light are **q** and $\mathbf{k}_i(\mathbf{k}_s)$, respectively.

TABLE I. Porosity, refractive index, and bulk acoustic phonon velocities for single layer porous silicon films.

Set no.	Porosity	Refractive index	V_T (km/s)	V_L (km/s)
1	0.59 ± 0.02	2.1 ± 0.1	2.1 ± 0.1	4.3 ± 0.2
	0.52 ± 0.03	2.4 ± 0.1	2.8 ± 0.2	4.6 ± 0.2
2	0.56 ± 0.02	2.2 ± 0.1	2.3 ± 0.2	4.2 ± 0.2
	0.46 ± 0.02	2.6 ± 0.2	2.7 ± 0.3	4.4 ± 0.3



SL spectra were collected at $5° \le \alpha \le 8°$, yielding, by

FIG. 3. Phonon frequency vs modulation wavelength (D) for superlattices

APPLIED PHYSICS LETTERS **99**, 171901 (2011)

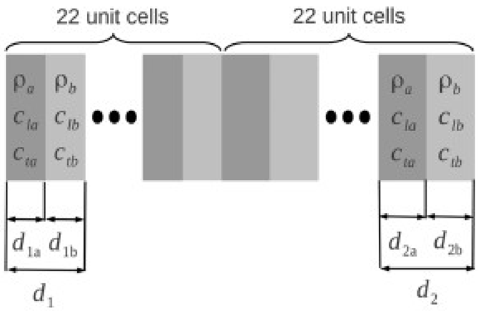
Existence of a giant hypersonic elastic mirror in porous silicon superlattices

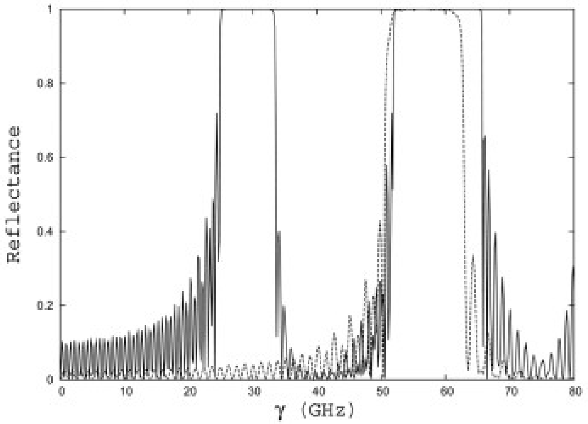
D. Moctezuma-Enriquez,[1,a)] Y. J. Rodriguez-Viveros,[1,a)] M. B. Manzanares-Martinez,[2]
P. Castro-Garay,[3,a)] E. Urrutia-Banuelos,[3] and J. Manzanares-Martinez[3,b)]
[1]*Centro de Investigacion en Materiales Avanzados (CIMAV), Miguel de Cervantes 120, Chihuahua 31109, Mexico*
[2]*Division de Ciencias e Ingenieria, Unidad Regional Sur, Universidad de Sonora, Blvd. Lazaro Cardenas 100, Navojoa, Sonora 85880, Mexico*
[3]*Departamento de Investigacion en Fisica, Universidad de Sonora, Apartado Postal 5-088, Hermosillo, Sonora 83180, Mexico*

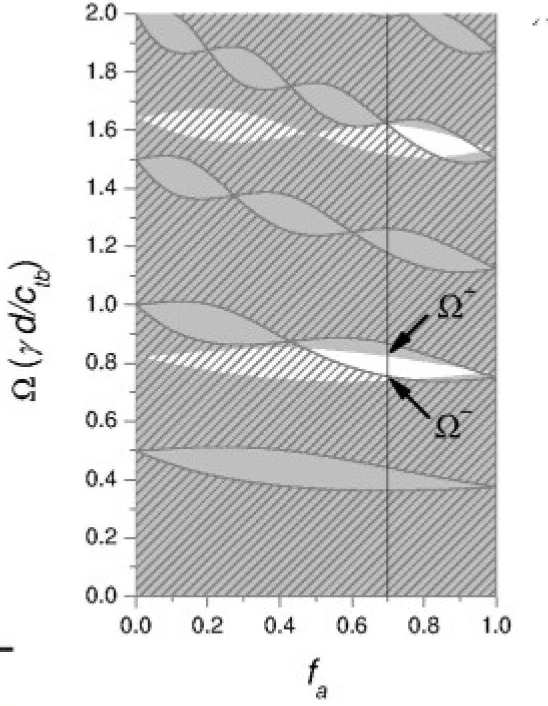
(Received 22 July 2011; accepted 3 October 2011; published online 24 October 2011)

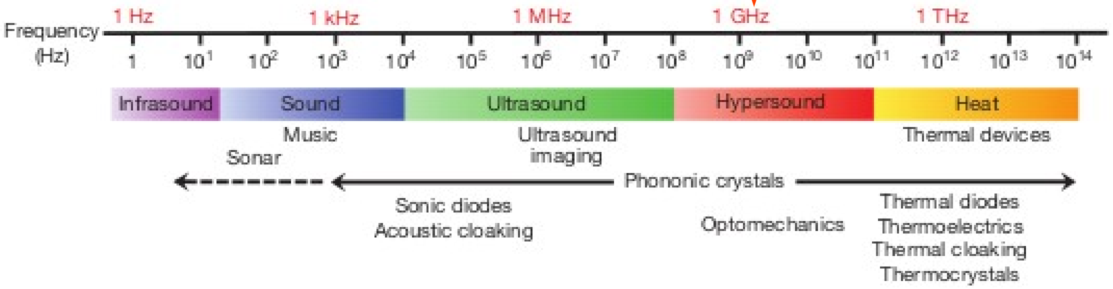
In this work, we theoretically predict the possibility to obtain a giant hypersonic elastic mirror in porous silicon superlattices by using a phononic heterostructure. The heterostructure is composed of a tandem of multiple phononic crystal lattices with periods in the range 37–167 nm, which recently have been experimentally reported [L. C. Parsons and G. T. Andrews, Appl. Phys. Lett. **95**, 241909 (2009)]. Considering the scalability of the eigenvalues of the elastic wave equation, the lattices are chosen such that each stop band can be superposed to obtain a larger overall stop band. Theoretical evidence of a giant hypersonic phononic mirror for longitudinal and transverse vibrations is found in the gigahertz range. *© 2011 American Institute of Physics.* [doi:10.1063/1.3655677]

$$-\omega^2\rho(\mathbf{x})u_i(\mathbf{x}) = \nabla\cdot\left[\rho(\mathbf{x})c_t^2(\mathbf{x})\nabla u_i(\mathbf{x})\right] + \nabla\cdot\left[\rho(\mathbf{x})c_t^2(\mathbf{x})\frac{\partial}{\partial x_i}\mathbf{u}(\mathbf{x})\right] + \frac{\partial}{\partial x_i}\left[\rho(\mathbf{x})c_l^2(\mathbf{x}) - 2\rho(\mathbf{x})c_t^2(\mathbf{x})\right]\nabla\cdot\mathbf{u}(\mathbf{x}),$$









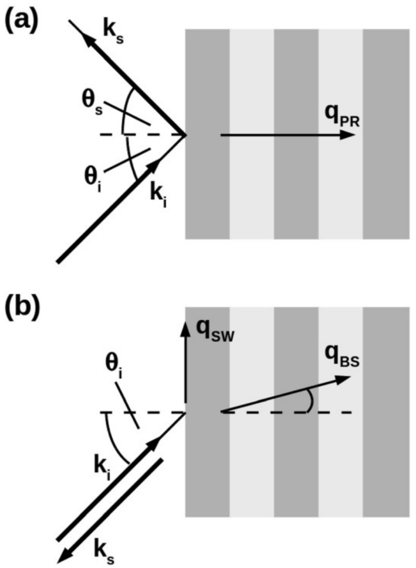
JOURNAL OF APPLIED PHYSICS 116, 033510 (2014)

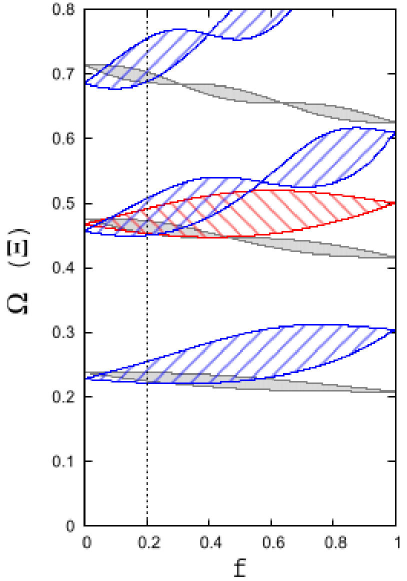
Off-axis phonon and photon propagation in porous silicon superlattices studied by Brillouin spectroscopy and optical reflectance

L. C. Parsons[a] and G. T. Andrews[b]
Department of Physics and Physical Oceanography, Memorial University of Newfoundland, St. John's, Newfoundland A1B 3X7, Canada

(Received 24 May 2014; accepted 3 July 2014; published online 17 July 2014)

Brillouin light scattering experiments and optical reflectance measurements were performed on a pair of porous silicon-based optical Bragg mirrors which had constituent layer porosity ratios close to unity. For off-axis propagation, the phononic and photonic band structures of the samples were modeled as a series of intersecting linear dispersion curves. Zone-folding was observed for the longitudinal bulk acoustic phonon and the frequency of the probed zone-folded longitudinal phonon was shown to be dependent on the propagation direction as well as the folding order of the mode branch. There was no conclusive evidence of coupling between the transverse and the folded longitudinal modes. Two additional observed Brillouin peaks were attributed to the Rayleigh surface mode and a possible pseudo-surface mode. Both of these modes were dispersive, with the velocity increasing as the wavevector decreased. *© 2014 AIP Publishing LLC.* [http://dx.doi.org/10.1063/1.4890319]





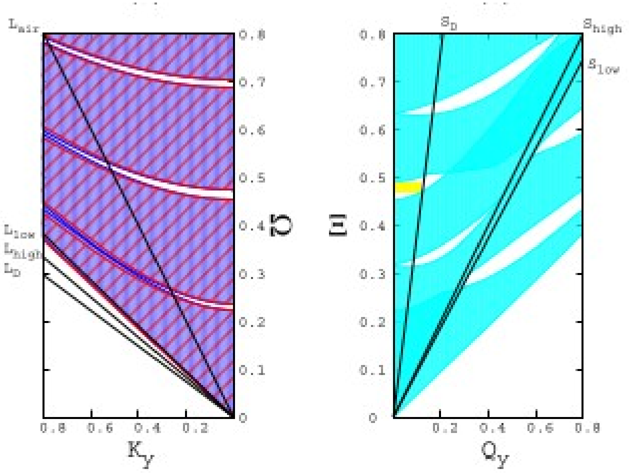
APPLIED PHYSICS LETTERS 101, 261902 (2012)

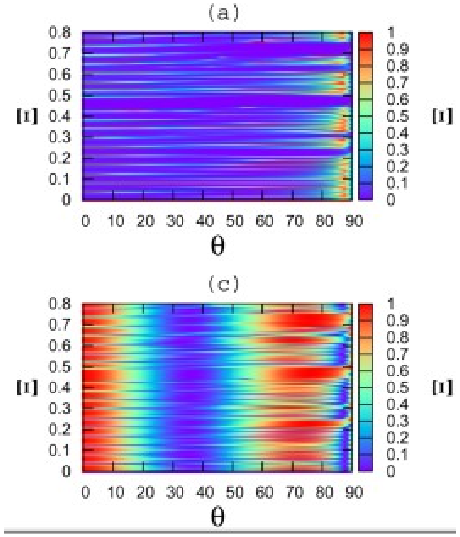
Non-perpendicular hypersonic and optical stop-bands in porous silicon multilayers

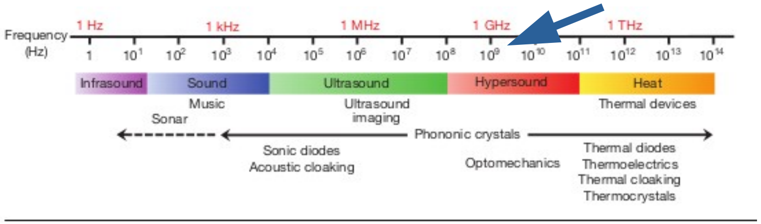
J. Manzanares-Martinez,[1,a] D. Moctezuma-Enriquez,[2,b] Y. J. Rodriguez-Viveros,[3] B. Manzanares-Martinez,[3] and P. Castro-Garay[3]
[1]*Departamento de Investigacion en Fisica, Universidad de Sonora, Apartado Postal 5-088, Hermosillo, Sonora 83180, Mexico*
[2]*Centro de Investigacion en Materiales Avanzados (CIMAV), Miguel de Cervantes 120, Chihuahua 31109, Mexico*
[3]*Departamento de Fisica, Universidad de Sonora, Blvd. Luis Encinas y Rosales, Hermosillo, Sonora 83180, Mexico*

(Received 21 September 2012; accepted 10 December 2012; published online 26 December 2012)

We study by theoretical simulations the non-perpendicular propagation of electromagnetic and elastic waves in porous silicon multilayers. We proceeded in three steps. First, we found the conditions to obtain a simultaneous photonic-phononic mirror at normal incidence. Second, we determined the angular variation of the mirrors computing the projected band structure. In a third step, we found out, on the one hand, that there are no conditions to obtain an omnidirectional mirror for electromagnetic waves. But, on the other hand, we found the conditions were possible to obtain an omnidirectional mirror for elastic waves. Moreover, the elastic mirror is revealed to be a polarization-converter due to the conversion of evanescent modes in the band gap. *© 2012 American Institute of Physics.* [http://dx.doi.org/10.1063/1.4773243]







PRL 110, 025902 (2013) PHYSICAL REVIEW LETTERS week ending 11 JANUARY 2013

Narrow Low-Frequency Spectrum and Heat Management by Thermocrystals

Martin Maldovan

Department of Materials Science and Engineering, Massachusetts Institute of Technology,
77 Massachusetts Avenue, Cambridge, Massachusetts 02139, USA

(Received 6 September 2012; published 9 January 2013)

By transforming heat flux from particle to wave phonon transport, we introduce a new class of engineered material to control thermal conduction. We show that rationally designed nanostructured alloys can lead to a fundamental new approach for thermal management, guiding heat as photonic and phononic crystals guide light and sound, respectively. Novel applications for these materials include heat waveguides, thermal lattices, heat imaging, thermo-optics, thermal diodes, and thermal cloaking.

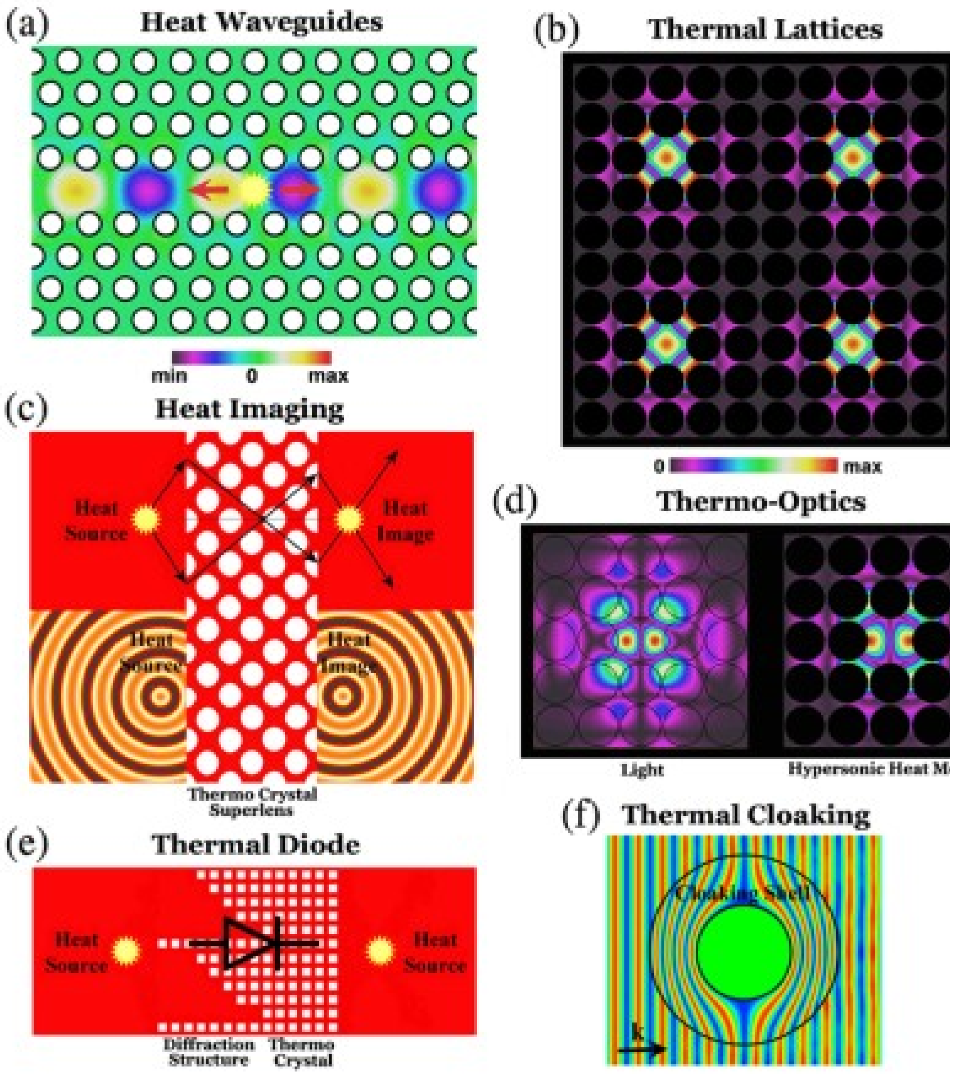


FIG. 3 (color online). Schematics for thermocrystals opportunities and challenges (a) *Heat waveguides*: A waveguide is created in a triangular lattice of air rods (white). Hypersonic heat modes (yellow) can be guided along the channel. Color scheme shows the displacement field for a hypersonic wave propagating in the waveguide. (b) *Thermal lattices*: Point defects are introduced in a square lattice of air rods (black) [18]. Hypersonic heat modes can be localized around the defects. Color scheme shows time averaged displacement fields for confined modes. (c) *Heat imaging*: Schematic of a heat source and its image across a thermocrystal superlense. Negative refracted [37] hypersonic beams (black arrows) focus the point source (yellow) located on one side of the lens into a real image on the other side. (d) *Thermo-optics*: A point defect in a thermocrystal (missing cylinder) can localize both light and hypersonic heat modes and enhance light-heat interactions. Color scheme shows time averaged fields for localized photon (left) and phonon (right) modes. (e) *Thermal diode*: Schematic of a diode made of a diffraction structure and a periodic array of cylinders [42]. Hypersonic heat modes from the right have smaller transmission than those from the left. The system can provide thermal rectification through nonreciprocal phonon propagation. (f) *Thermal cloaking*: Acoustic pressure field for a cylindrical scatterer surrounded by a cloaking shell (adapted from Ref. [43]). The development of metamaterials for elastic waves can lead to low temperature thermal cloaking.

nature materials

PROGRESS ARTICLE
PUBLISHED ONLINE: 23 JUNE 2015 | DOI: 10.1038/NMAT4308

Phonon wave interference and thermal bandgap materials

Martin Maldovan[1,2]

Wave interference modifies phonon velocities and density of states, and in doing so creates forbidden energy bandgaps for thermal phonons. Materials that exhibit wave interference effects allow the flow of thermal energy to be manipulated by controlling the material's thermal conductivity or using heat mirrors to reflect thermal vibrations. The technological potential of these materials, such as enhanced thermoelectric energy conversion and improved thermal insulation, has fuelled the search for highly efficient phonon wave interference and thermal bandgap materials. In this Progress Article, we discuss recent developments in the understanding and manipulation of heat transport. We show that the rational design and fabrication of nanostructures provides unprecedented opportunities for creating wave-like behaviour of heat, leading to a fundamentally new approach for manipulating the transfer of thermal energy.

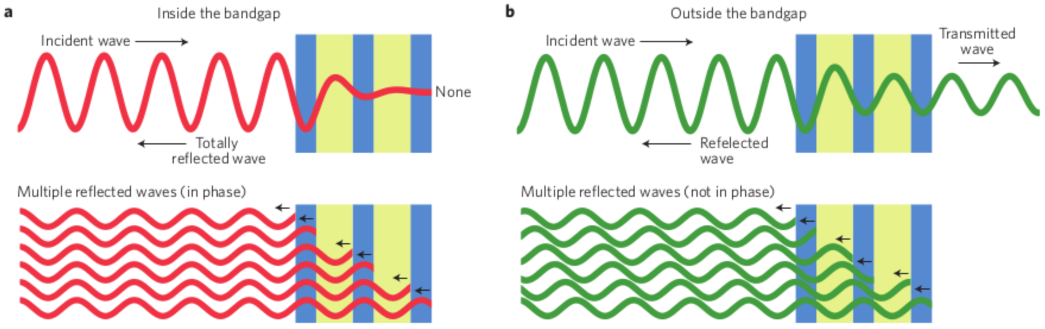


Figure 1 | The bandgap principle. a, When a wave is incident on a periodic material, multiple reflected waves are created at the interfaces. If these waves are in phase, they interfere constructively and thus prevent the original wave from propagating within the structure. **b**, If the multiple reflected waves are not in phase, they do not interfere constructively and the original wave is allowed to propagate. The range of frequencies for which the original wave is forbidden from propagating within the structure is known as the bandgap. Figure adapted with permission from Slim Films.

heat spectrum. Heat mirrors that provide all-angle wave reflection do not necessarily require three-dimensional periodic structures. One-dimensional multilayer systems can be designed to achieve all-angle reflection for external thermal vibrations[79–82]. It is important to mention that although thermal bandgaps provide unprecedented physical effects, such as the reflection of external thermal vibrations, most work so far has been focused on their effects on internal thermal vibrations[17–21].

Conclusions and outlook

Over the past few decades, control of thermal energy flow has been achieved through the introduction of structural defects that scatter thermal vibrations diffusely, such as atomic-scale impurities, interfaces, surfaces and nanoparticles. In this Progress Article, we have described a recent and fundamentally different approach in which thermal vibrations are specularly reflected and transmitted at interfaces, thereby enabling wave interference and the creation of thermal bandgaps. A variety of theoretical and experimental methods have recently been employed to design and fabricate nanostructures that can control heat flow through wave interference effects. These approaches include manipulating the heat phonon frequency spectrum, using low-temperature systems, and fabricating nanostructures with atomically smooth interfaces.

79. Fink, Y. *et al.* A dielectric omnidirectional reflector. *Science* **282,** 1679–1682 (1998).
80. Winn, J. N., Fink, Y., Fan, S. H. & Joannopoulos, J. D. Omnidirectional reflection from a one-dimensional photonic crystal. *Opt. Lett.* **23,** 1573–1575 (1998).
81. Bria, E. & Djafari-Rouhani, B. Omnidirectional elastic band gap in finite lamellar structures. *Phys. Rev. E* **66,** 056609 (2002).
82. Manzanares-Martinez, B. *et al.* Experimental evidence of omnidirectional elastic band gap in finite one-dimensional phononic systems. *Appl. Phys. Lett.* **85,** 154–156 (2004).

Nanoscience and Nanotechnology Letters
Vol. 11, 1–7, 2019

Omnidirectional THz Mirror on a One-Dimensional Porous Silicon Thermocrystal

B. Manzanares-Martínez[1] and J. Manzanares-Martinez[2,*]

[1] *Departamento de Fisica, Universidad de Sonora, Blvd. Luis Encinas y Rosales, Hermosillo, Sonora 83000, Mexico*
[2] *Departamento de Investigacion en Fisica, Universidad de Sonora, Blvd. Apartado Postal 5-088, Hermosillo, Sonora 83000, Mexico*

We have de designed a thermocrystal that reflects phononic thermal radiation. In the THz range, heat is kinetic energy carried predominantly by phononic vibrations. These mechanical vibrations have wavelengths that produces interferences within the internal interfaces of a phononic crystal. We determined conditions to obtain gaps simultaneously for longitudinal and transverse waves in a porous silicon multilayer. We propose a one-dimensional crystal with an omnidirectional mirror that reflects all phononic vibrations in the THz.

Keywords: Thermocrystal, Phononic Crys

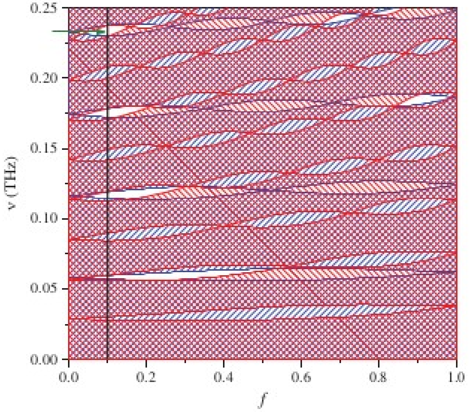


Fig. 1. Map of bands as function of the filling fraction f. The blue and red line-patterns represent the allowed bands for longitudinal and transverse polarization, respectively.

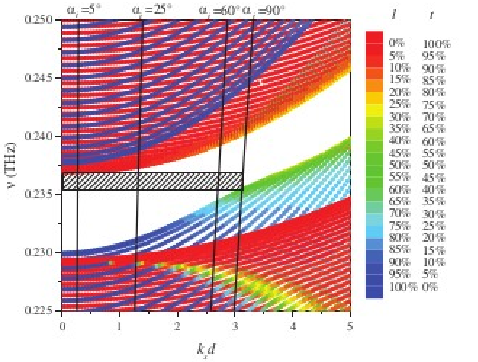


Fig. 2. Projected band structure of the sagittal polarization. The color maps correspond to longitudinal and shear modes. Black lines are the k_x components of a wave impinging from diamond with angles $\alpha_i = 5°$, 25°, 60° and 90°.

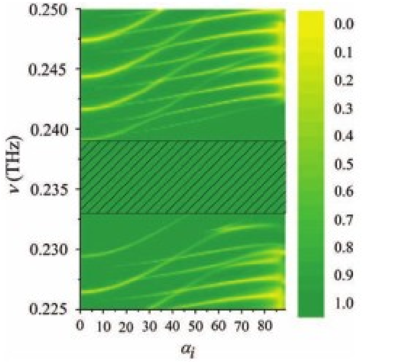


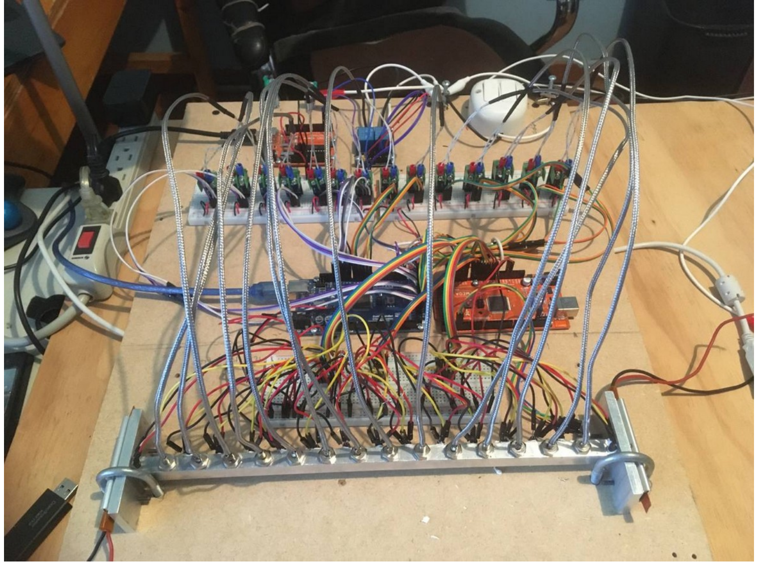
Fig. 4. Reflection of a heterostructure composed of three $(d_s d_i)^6$ porous silicon multilayers with periods of $d = 36.7$ nm, 37 nm, and 37.3 nm. An omnidirectional mirror exists for the black line-pattern area.

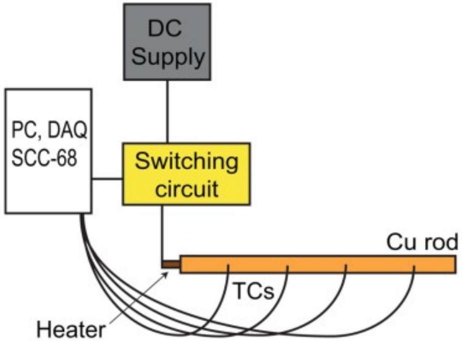
Fourier analysis of thermal diffusive waves

Muhammad Sabieh Anwar,[a)] Junaid Alam, Muhammad Wasif, Rafi Ullah, Sohaib Shamim, and Wasif Zia
Department of Physics, Syed Babar Ali School of Science and Engineering, Lahore University of Management Sciences (LUMS), Opposite Sector U, D. H. A., Lahore 54792, Pakistan

(Received 18 December 2012; accepted 22 May 2014)

We present details of an experiment that improves earlier attempts to study the propagation of diffusive thermal waves inside a metal rod. In addition to technical improvements in data acquisition and heater control, the experiment physically illustrates insightful concepts in Fourier analysis. For example, the harmonic content and the differential damping of harmonics can be observed in the thermal domain, thus providing a valuable extension to the standard Fourier analysis of electric circuits.
[http://dx.doi.org/10.1119/1.4881608]





(a)

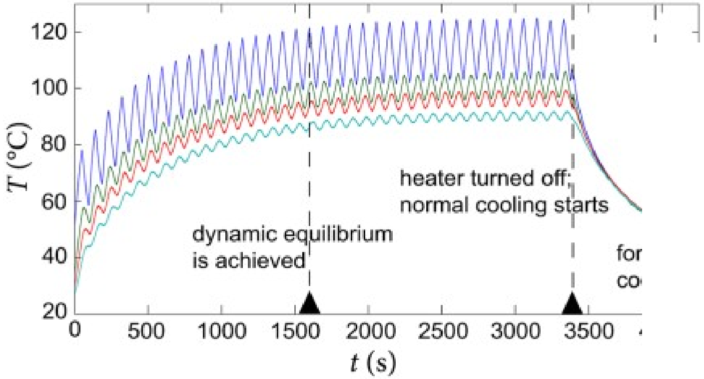
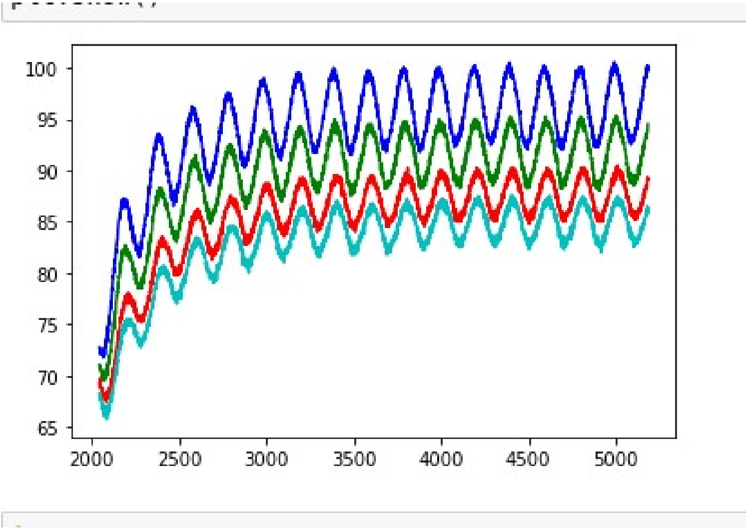
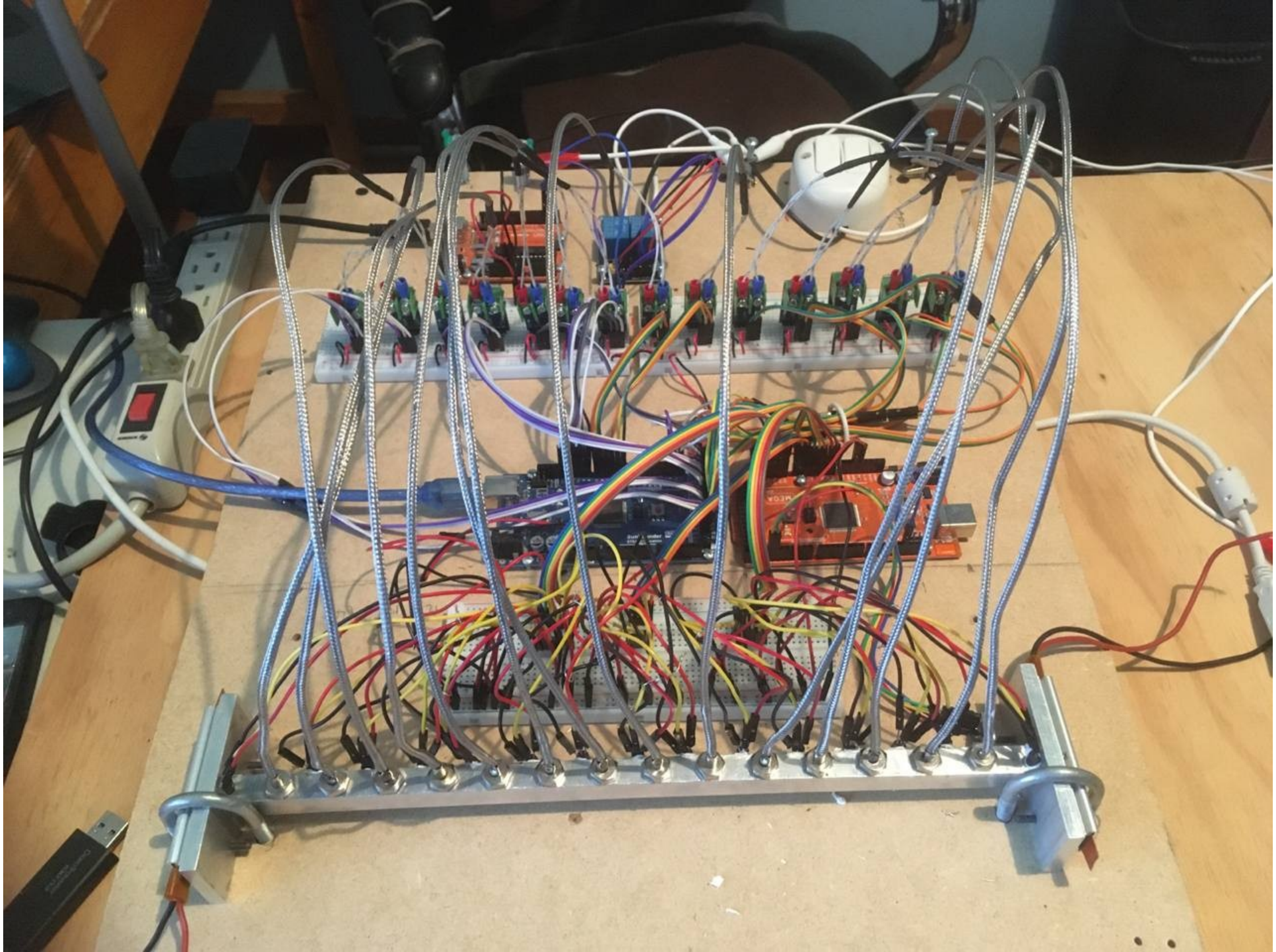


Fig. 2. Temperature oscillations at different points along the copper
thermocouples closer to the heat source have higher average temp
A dynamic equilibrium is reached after about 30 min. At around 55
heater is switched off permanently and the assembly is allowed to c
under ambient conditions and then in the presence of a cooling fan.





Results in Physics 30 (2021) 104856

Contents lists available at ScienceDirect

Results in Physics

journal homepage: www.elsevier.com/locate/rinp

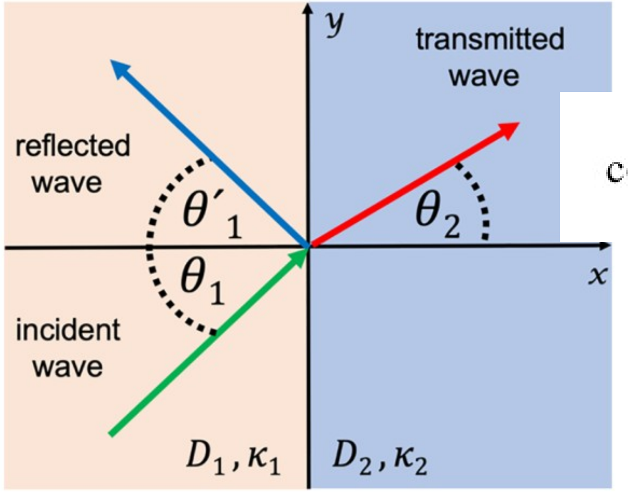
Brewster angle of thermal diffusivity waves at an interface

Cesar Augusto Romero-Ramos [a], Jesús Manzanares-Martínez [b,*], Betsabe Manzanares-Martínez Diego Soto-Puebla [b], Gerardo Alejandro Morales-Morales [a], Carlos Eduardo Ruiz-Rosales [a]

[a] Posgrado en Ciencias (Fisica), Universidad de Sonora, Apartado Postal 5-088, Hermosillo, Sonora 83180, Mexico

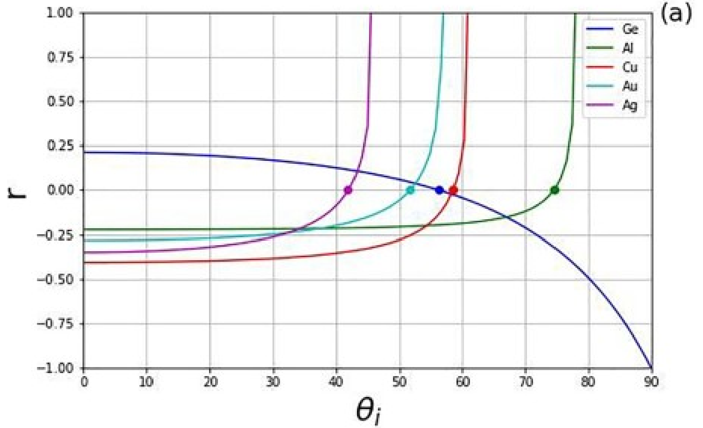
[b] Departamento de Investigacion en Fisica, Universidad de Sonora, Blvd. Luis Encinas y Rosales, Hermosillo, Sonora 83000, Mexico

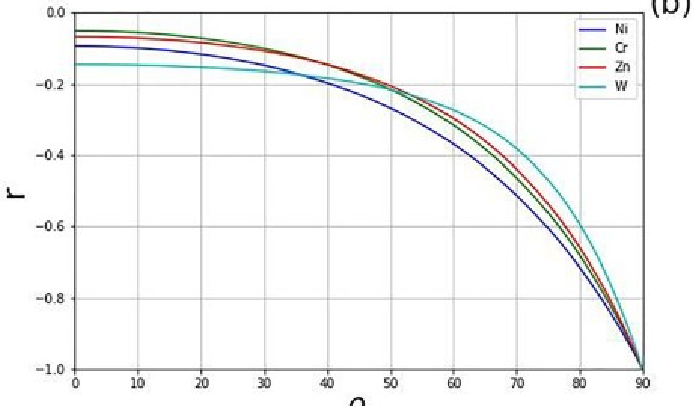
[c] Departamento de Fisica, Universidad de Sonora, Blvd. Luis Encinas y Rosales, Hermosillo, Sonora 83000, Mexico



$$\cos^2\theta_B = \frac{D_1/D_2 -}{\kappa_1^2/\kappa_2^2 - 1}$$

		Transmission medium									
		Ni	Cr	Ge	Zn	W	Si	Al	Cu	Au	Ag
Incidence medium	Ni					17.28		20.08	23.06	19.11	17.59
	Cr				21.22	26.03		25.57	27.04	23.19	20.78
	Ge				61.32	41.67	31.26	35.04	32.05	29.71	25.38
	Zn		25.68	74.23		33.24		31.66	33.18	28.25	25.12
	W	30.83	42.21	68.85	44.51			40.67	44.40	35.46	31.51
	Si			56.31				74.53	58.56	51.78	41.97
	Al	43.81	50.56	70.25	51.68	49.60	80.23		56.24	38.48	35.08
	Cu	62.02	65.40	76.58	66.13	66.10	77.28	68.26			
	Au	50.44	55.40	71.68	55.74	52.38	69.81	46.63			39.83
	Ag	56.31	60.08	73.60	60.03	56.25	69.02	51.70		48.46	





Quieren venir a hacer su maestria y/o doctorado con nosotros?
Tenemos becas para estudiantes nacionales y extranjeros

http://www.posgrado.cifus.uson.mx/

Esta presentacion esta disponible en http://manza.space, me pueden contactar a jesus.manzanares@unison.mx http://www.posgrado.cifus.uson.mx/wp-content/uploads/2021/11/Convocatoria-Posgrado-Fisica_2022-2.pdf

http://www.posgrado.cifus.uson.mx/wp-content/uploads/2021/02/Convocatoria-Propes-2021.pdf

UNIVERSIDAD DE SONORA

DIVISIÓN DE CIENCIAS EXACTAS Y NATURALES
Departamento de Investigación en Física

Programa acreditado en el PNPC CONACYT

CONVOCATORIA 2022-2

Para ingresar al

POSGRADO EN CIENCIAS (FÍSICA)

Y elaborar investigación en una de las siguientes Líneas de Generación y Aplicación del Conocimiento:

- *Física del Estado Sólido*
- *Física de Materiales*
- *Óptica y Electrodinámica*
- *Física Matemática.*

Mayor información: Página web: posgrado.cifus.uson.mx

REQUISITOS INGRESO MAESTRÍA (PNPC NIVEL COMPETENCIA INTERNACIONAL)

1) Licenciatura en Ciencias Físicas o carrera afín con conocimientos suficientes en Física Básica. Promedio mínimo de calificaciones de 80 puntos (en escala de 0 a 100).
2) Nivel CUATRO de los cursos de inglés del Departamento de Lenguas Extranjeras o bien 400 Puntos del TOEFL ITP o equivalente.
3) Presentar y aprobar un examen de admisión sobre las materias básicas de Física (Mecánica Clásica, Mecánica Cuántica, Física Térmica y Electromagnetismo) según el temario impartido en los Cursos Propedéuticos. Este examen podrá acreditarse mediante constancia de aprobación de los Cursos Propedéuticos de un Programa de Maestría en Física con una anterioridad menor a un año y medio.
4) Recibir una evaluación positiva en la entrevista individual con la Comisión Académica donde se evaluará la competitividad del aspirante para realizar estudios de Maestría.
5) Acreditar un puntaje mínimo de 1000 puntos en el examen de conocimientos y aptitudes EXANI III (consultar: https://ceneval.edu.mx/examenes-ingreso-exani_iii/).

REQUISITOS INGRESO DOCTORADO (PNPC NIVEL CONSOLIDADO)

1) Maestría en Ciencias Físicas o Maestría afín con conocimientos suficientes en Física Básica. Promedio mínimo de calificaciones de 80 puntos (en escala de 0 a 100).
2) Nivel CUATRO de los Cursos de Inglés del Departamento de Lenguas Extranjeras o bien 400 Puntos del TOEFL ITP o equivalente.
3) Presentar y aprobar un examen de admisión sobre las materias básicas de Física (Mecánica Clásica, Mecánica Cuántica, Mecánica Estadística y Electromagnetismo). Este examen podrá acreditarse mediante constancia de haber cursado las materias correspondientes en un programa de Maestría en Física con anterioridad menor a dos años.
4) Recibir una evaluación positiva en la entrevista individual con la Comisión Académica donde se evaluará la competitividad del aspirante para realizar estudios de Doctorado.

REGISTRO Y SELECCIÓN DE ESTUDIANTES:

- El registro de aspirantes serán en línea en la plataforma de la Universidad de Sonora en la dirección electrónica https://aspirantesposgrado.uson.mx

UNIVERSIDAD DE SONORA

"El saber de mis hijos hará mi grandeza"

DIVISIÓN DE CIENCIAS EXACTAS Y NATURALES
Departamento de Investigación en Física

El Programa de Posgrado en Ciencias (Física)

Invita

A participar en los

CURSOS PROPEDÉUTICOS DEL PROGRAMA DE MAESTRÍA EN CIENCIAS (FÍSICA)

(Requisito de ingreso obligatorio al programa para egresados de las ingenierías)

Carácter: Optativo para egresados de la licenciaturas e ingenierías en Física, y obligatorio para aspirantes de ingenierías afines. Sin Valor curricular.

Duración: 180 Horas

Periodo: 01 de marzo al 28 de mayo del 2021.

Objetivo General: Actualizar y homogeneizar los conocimientos en áreas de Física Básica

Objetivos Específicos: Proporcionar conocimientos de nivel licenciatura en las materias: Métodos Matemáticos de la Física, Mecánica Clásica, Mecánica Cuántica, Física Témica y Electromagnetismo a licenciados en áreas afines a las Ciencias Físicas. Brindar la opción de acreditación de los cursos propedéuticos para el ingreso al Programa de Maestría, de acuerdo a la Convocatoria publicada.

Perfil de los alumnos: Egresados en carreras de Ingeniería, Química, Químico-Biólogo, Biología y Matemáticas interesados en profundizar sus conocimientos en Física y Licenciados en Física interesados en su actualización.

Requisitos de idiomas: Capacidad de lectura de textos técnicos en Física en idioma de inglés. Se acreditará mediante una prueba de traducción.

Cupos: Mínimo CUATRO, Máximo VEINTE.

Estructura de los cursos: CINCO materias independientes con un total de TREINTA Y SEIS horas cada una impartidas en TRES horas semanales. Mientras las autoridades universitarias no autoricen actividades presenciales, todos los cursos serán impartidos por videoconferencia.

Requisito de Evaluación y Acreditación: La evaluación de cada materia se realizará mediante tres exámenes parciales. Cada materia deberá aprobarse independientemente con un promedio igual o mayor a 80 (en escala de 0 a 100). Además, para la acreditación del curso será necesario el 90 % de asistencia.

Materia 1. Métodos Matemáticos de la Física

- Análisis Vectorial
- Matrices y determinantes
- Series
- Funciones de variable compleja
- Ecuaciones diferenciales parciales

Esta presentacion esta disponible en http://manza.space, me pueden contactar a jesus.manzanares@unison.mx

Si existe alguien interesado en hacer su maestria o doctorado en la Universidad de Sonora,
Me puede contactar en

jesus.manzanares@unison.mx

http://manza.space

Twitter @phoxonic