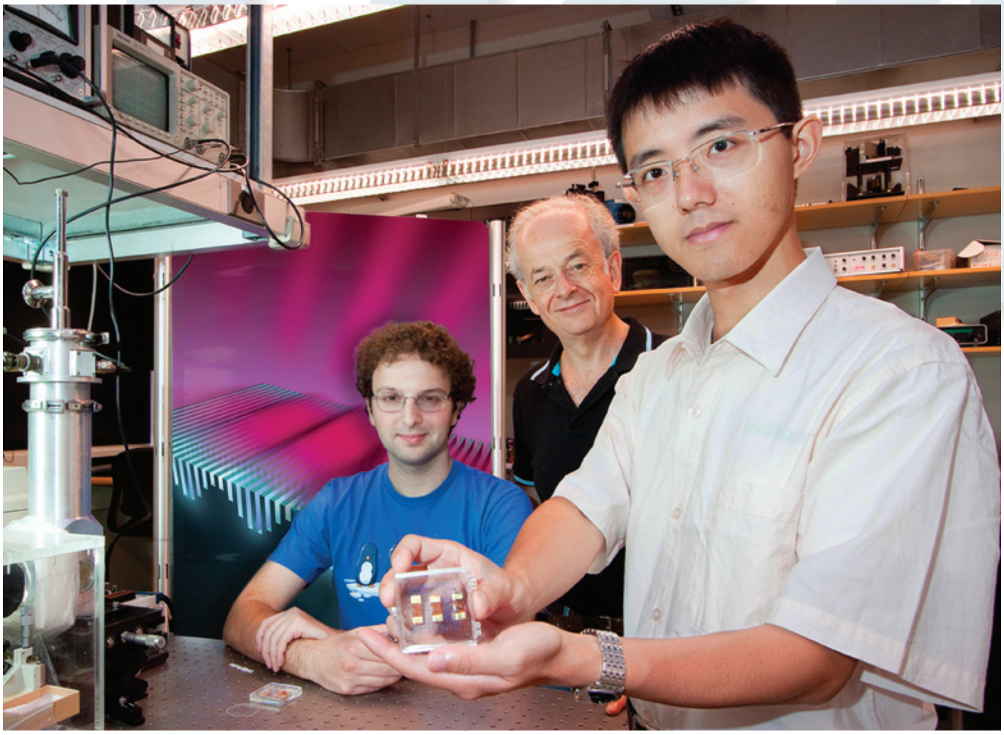
Professor Federico Capasso

Harvard University



Professor Federico Capasso (centre), Dr Nanfang Yu (right) and graduate student Mikhail Kats (left) in the Capasso Laboratory in the School of Engineering and Applied Science at Harvard University

FEDERICO CAPASSO is the Robert Wallace Professor of Applied Physics in the School of Engineering and Applied Sciences at Harvard University, Cambridge, MA. He is a member of the US National Academy of Sciences and of the National Academy of Engineering, and a Fellow of: the American Academy of Arts and Sciences; the Institute of Physics (UK); the Optical Society of America; the Institute of Electrical and Electronic Engineers; and the American Physical Society. He won the 2010 Berthold Leibinger Zukunft Prize (Future); the 2005 King Faisal International Prize for Science; the 2005 Gold Medal of the President of Italy for meritorious achievement in science; the 2004 Edison Medal, Institute of Electrical and Electronic Engineers (IEEE); and the 2004 Arhur Schawlow Prize in Laser Science of the American Physical Society.

Q. What inspired you to become a researcher?
A. My dad, when I was six years old, gave me a book entitled *Our friend the Atom*, by Heinz Haber, a gifted science writer. I got hooked and though I never showed an early talent in science, I decided on the spot that I would be a physicist; that was it: I never had a doubt that there could be anything more exciting than the thrill of discovery. Yes, the fun part was a key driver.

Q. How did you get started in your academic career?
A. After completing my doctorate I decided I did not want to work in academia as in Italy politics and bureaucracy was (and still is) putting unreasonable obstacles in the career of ambitious and talented young people. So I decided to spend two years in a telecom government laboratory; I gained experience in fibre optics, and then, at the first opportunity, I landed in United States at Bell Labs in 1976. This was then the 'Mecca' of industrial research spanning the whole range from basic science to applications. I had an exciting career there but when the call came from Harvard University in 2002 I could not resist, knowing the wonderful research environment there. It has also been a great change working with students and teaching.

Q. When did you start working in the terahertz field?
A. In the late nineties a new frontier of quantum cascade laser (QCL) research was to make a terahertz laser. The top QCL groups then started to push hard in that direction. I was brilliantly scooped by the team led by Alessandro Tredicucci (in Pisa, Italy), and Edmund Linfield.

Q. Has the terahertz field developed as you might have expected? What have been the biggest surprises?
A. To be honest, though a lot of excellent research has been done by many groups, the impact of terahertz QCLs has been far less than mid-infrared QCLs. The latter have far better performance in terms of optical power, tunability and broadband operation, and most importantly, can operate continuous-wave and pulsed at room temperature with high power.

Q. Tell us a little bit about your current research activities.
A. My research on QCLs centres on developing new broadband sources, and in particular broadband mid-infrared spectrometers on a chip; high power/high power efficiency continuous-wave QCLs, beam engineered QCLs, as well new terahertz sources based on intracavity difference frequency generation. A significant portion of my QCL research is industry driven through collaborations with major industrial players. I also have a fairly large effort in plasmonics and metamaterials where we are exploring both novel phenomena, device applications and new fabrication techniques based on soft lithography and colloidal chemistry. In particular, we have recently shown that by structuring the facet of a terahertz QCL as a metamaterial, the normally highly divergent terahertz radiation can be highly collimated. Finally, we are investigating optical forces that arise between waveguides and other photonic components in close proximity, as well as quantum electrodynamical forces generated by quantum fluctuations of vacuum and matter, such as the Casimir effect.

Q. Within your research in the terahertz area, what are the key challenges?
A. The biggest challenge remains achieving operation at thermoelectric cooler temperature, and then at room temperature in both pulsed and continuous-wave mode.

Q. It has often been said that 'terahertz is a solution looking for a problem' - do you agree?
A. Largely yes: I don't yet see compelling applications that can drive new markets.

Q. What do you see as the prospects for exploiting terahertz technology, and what are the key barriers? What one key thing would transform the terahertz field? What are the potential applications that you find the most exciting?
A. These are all connected questions. Until a compact solid-state laser with excellent performance, at least operating under thermoelectric cooling in pulsed and continuous-wave is achieved, I don't see prospects for real applications except basically in small niches. If these barriers can be overcome then security applications such as the search for concealed weapons and explosives, and other applications such as materials diagnostics could become important.