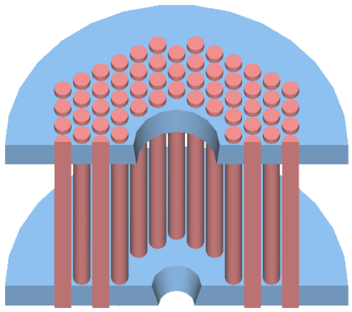
Towards Building Terahertz Microwave Sources



Section of the PBG resonator.

All electron beam device microwave sources convert the kinetic energy in an electron beam to electromagnetic waves inside a resonator. The rapidly shrinking transverse size of resonators (dimensions are smaller than the operating wavelength) with increasing frequency poses a serious obstacle for fabrication and thermal dissipation.

Recently, researchers at the Plasma Science and Fusion Center at MIT have demonstrated a new technique for building high frequency microwave sources with transverse resonator dimensions many times the operating wavelength. Traditional larger dimension resonators operating in a higher order mode, invite competition from the lower order modes thus reducing the stability and purity of the generated microwaves. The novel resonator was made of a photonic band gap (PBG) structure, a two dimensional array of metal posts which reflects only certain frequencies while being transparent to other frequencies allowing a much larger sized resonator to support only one higher order mode while eliminating all other unwanted modes in the vicinity of the operating mode. The PBG resonator was formed from a triangular lattice of 121 metal posts from which the inner 19 posts were removed to localize the electromagnetic mode.

The potential of PBG resonators was demonstrated in a high frequency laser-like gyrotron oscillator experiment at 140 GHz, which exhibited oscillations at only a single frequency over a wide range of operating parameters corresponding to a frequency range of 30 % around 140 GHz. The device produced a peak power of 25 kW at an operating voltage of 68 kV and 5 A beam current. This highly stable mode-selective operation of a PBG resonator opens up new avenues for extending the operating frequencies of all classes of microwave tubes such as klystrons, traveling wave tubes etc. into the Terahertz regime by using overmoded resonators which are larger and easier to fabricate. This technique of mode control is also applicable to a variety of passive devices such as antennas and waveguides. The work is supported by the Department of Defense under the MURI for Innovative Microwave Vacuum Electronics and the Office of Fusion Energy Sciences of the Department of Energy. The work has been published in Physical Review Letters, vol. 86, p. 5628, 11 June 2001. See also Physical Review Focus (http://focus.aps.org/v7/st28.html). For more information please contact Jagadishwar Sirigiri (jags@psfc.mit.edu, 617-253-8619), Michael Shapiro (shapiro@psfc.mit.edu, 617-253-8656) and Richard Temkin (temkin@psfc.mit.edu, 617-253-5528).