Surface and volume mode coupling experiments for high power mm-wave sources

A J MacLachlan[1], A R Phipps[1], I V Konoplev[2], C W Robertson[1], A W Cross[1] and A D R Phelps[1]
[1]Department of Physics, SUPA, University of Strathclyde, Glasgow, G4 0NG, Scotland, UK
[2]JAI, Department of Physics, University of Oxford, Oxford, OX1 3RH, England, UK

The principles of wave dispersion and mode coupling are well-established in plasma physics and can also be applied to the realisation of novel high power mm-wave radiation sources. The terms “dispersion engineering” and “transformational electromagnetics” are used to describe these methods in novel electromagnetic radiation source development.

In the present work, a comparison of theory, modelling and measurements of periodic surface lattice (PSL) structures [1] is reported. In situations where a structure may support several modes, volume and surface wave coupling can result in the formation of a stable eigenmode. The formation of such eigenmodes is relevant to improved mode selectivity and the realization of high power mm-wave and THz coherent sources [2-4].

The cavity dimensions of traditional electromagnetic sources tend to decrease as the wavelength of the source radiation decreases, in order to keep the excited cavity mode as a single low order mode thus avoiding less efficient multi-mode excitation. This in turn limits the output power of mm-wave and THz sources, compared with corresponding RF and microwave sources. An approach that can be used to mitigate this is to introduce methods of mode selection in over-moded cavities. The specific method studied here uses periodic surface lattices (PSLs) created by manufacturing shallow periodic perturbations on a metal surface. Periodic structures can be one, two or three dimensional. The present study employs two dimensional (2D) periodic perturbations to couple surface modes to volume modes in an overmoded structure to create a well-defined eigenmode.

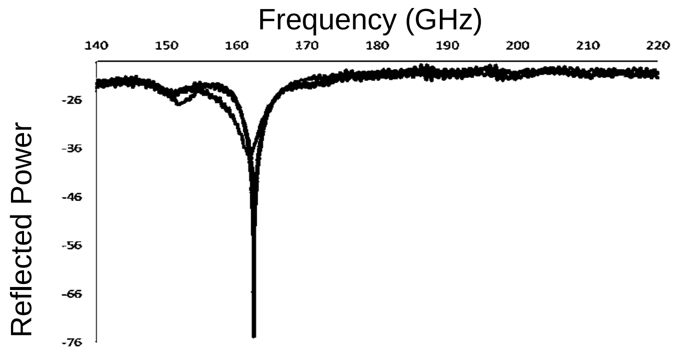

Figure 1. Experimental measurement showing coherent eigenmode formation

In a “proof-of-principle” experiment it has been demonstrated that it is possible to form a stable eigenmode by mode-locking surface and volume modes, as shown in Fig. 1. These results are supporting the design of future millimetre-wave radiation sources in the 100GHz to 1THz frequency range for several potential applications, including plasma diagnostics.

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