THE RIPPLED-FIELD MAGNETRON
(CROSS-FIELD FREE ELECTRON LASER)

F. Hartemann,† G. Bekefi, and R.E. Shefer

Department of Physics and Research Laboratory of Electronics
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

ABSTRACT

Millimeter wave emission from the rippled-field magnetron (cross-field free electron laser) is investigated experimentally and theoretically. In this device, electrons move in quasi-circular orbits under the combined action of a radial electric field, a uniform axial magnetic field, and a radial, azimuthally periodic wiggler magnetic field. In excess of 300kW of RF power is observed in two narrow spectral lines whose frequency can be tuned continuously from ~25GHz to ~50GHz by variation of the axial magnetic field. The observations are interpreted as a free electron laser type of instability, associated with a resonance in the particle motion, which is shown to occur when

$$2k_\text{w}v_\text{o}z = \left(\omega_\text{p}/\omega_\text{o}\right) \sqrt{1-(\omega_\text{p}/\omega_\text{o})^2},$$

where $k_\text{w}$ is the wiggler wavenumber, $v_\text{o}$ is the azimuthal electron velocity, $\omega_\text{o}$ is the relativistic cyclotron frequency in the axial magnetic field, $\omega_\text{p}$ is the relativistic plasma frequency, and $\gamma_o = [1-(v_o/c)^2]^{-\frac{1}{2}}$.

†Permanent address: Laboratoire de Physique des Gaz et des Plasmas, Université Paris XI, Centre Scientifique d'Orsay, France.