space periodic heating of the lattice on pico-second timescale, leading to periodic ablation of the material and creation of grating structures.

Consider a metal–free space interface, $x = 0$, with free space as region I ($x > 0$) and metal of effective permittivity $\varepsilon$ as region II ($x < 0$). Two SPWs of equal frequencies propagate along the surface at angles $\theta$ and $-\theta$ to $z$-axis (Figure 1).

The fields of the two SPWs are,

$$\vec{E}_1 = \vec{F}_1(x) \exp[-i(\omega t - k\sin\theta y - k\cos\theta z)],$$

$$\vec{E}_2 = \vec{F}_2(x) \exp[-i(\omega t + k\sin\theta y - k\cos\theta z)],$$  \hspace{1cm} (1)

where

$$\vec{F}_{1,2}(x) = A \left( \frac{k}{i\alpha_2} \hat{x} \pm \sin\theta \hat{y} + \cos\theta \hat{z} \right) e^{-\alpha_1 x} \quad \text{for } x > 0,$$

$$= A \left( \frac{k}{i\alpha_2} \hat{x} \pm \sin\theta \hat{y} + \cos\theta \hat{z} \right) e^{\alpha_2 x} \quad \text{for } x < 0,$$

$$\alpha_1 = k^2 - \omega^2/c^2, \quad \alpha_2 = k^2 - \omega^2/\varepsilon c^2, \quad k^2 = (\omega^2/c^2)/[\varepsilon(1 + \varepsilon)], \quad \varepsilon \equiv \varepsilon_l - \omega_0^2/\omega^2; \ v_l \text{ is the lattice permittivity and } \omega_0 \text{ is the plasma frequency. The total field inside the metal is}$$

$$\vec{E} = \vec{E}_1 + \vec{E}_2 = Ae^{i\omega t}\left[ \frac{2k}{i\alpha_2} \cos(k\sin\theta y) + \frac{k}{\varepsilon} \frac{\sin\theta \sin(k\sin\theta y)}{\sin(k\sin\theta y)} \right].$$  \hspace{1cm} (3)

This field imparts an oscillatory velocity $\vec{v}$ to free electrons. Solving the equation of motion $m(d\vec{v}/dt) = -e\vec{E} - mv\vec{v}$ we obtain,

$$\vec{v} = \frac{e\vec{E}}{mi(\omega + iv)},$$  \hspace{1cm} (4)

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where \( e, m \) and \( \nu \) are electronic charge, mass and momentum transfer collision frequency. The SPWs heat the electrons at a time average rate \( R = -e\vec{E} \cdot \vec{\nu} \) where \( \star \) denotes the complex conjugate and real part of \( R \) is implied. Using eqs (3) and (4), one may write \( R \) as

\[
R = \frac{ve^2A^2}{m\omega^2} e^{2\alpha_x \cdot \varepsilon} \left[ e - 1 - \cos(2k \sin \theta y) \right] e^{2\alpha_x \cdot \varepsilon},
\]

where we have assumed \( \nu^2 \ll \omega^2 \). A steady state is reached when heating rate is balanced by the energy loss rate through electron–phonon collisions and thermal conduction,

\[
R = -V_x (\chi_e V T_e) + \frac{3}{2\tau_e} (T_e - T_0),
\]

where \( \chi_e \) is the electron thermal conductivity, \( T_0 \) is the lattice temperature and \( \tau_e \) is the energy relaxation time. Assuming \( \chi_e \tau_e \gg \alpha_x^2, k^{-2} \), and \( \chi_e \) to be constant, the solution to eq. (6) can be written as

\[
T_e = T_0 + T_1 e^{\alpha x \cdot \varepsilon} + T_2 e^{2\alpha x \cdot \varepsilon} + T_3 e^{2\alpha x \cdot \varepsilon} \cos(2k \sin \theta y),
\]

where

\[
T_1 = T_{es} - T_0 - T_1, \quad T_1 = \frac{ve^2A^2(1 - \varepsilon)}{4m\omega^2\alpha_x^2\chi_e}, \quad \alpha_0 = \frac{2}{3\tau_e \chi_e} T_2 = \frac{ve^2A^2(1 - \varepsilon \cos 2\theta)}{4m\omega^2(\alpha_x^2 - k^{-2} \sin^2 \theta)} \chi_e, \quad \text{and} \quad T_{es} \text{ is the y-averaged surface temperature of electrons. At } x = 0, \ T_e \text{ may be written as}
\]

\[
T_e = T_{es} + T_1 \cos(2k \sin \theta y).
\]

The rate of thermionic emission of electrons per unit area per second is given by Richardson formula\(^5\),

\[
I = C_1 T_e^2 e^{-\phi/T_e},
\]

where \( \phi \) is the work function of the metal and \( T_e \) is given by eq. (8). The periodicity of \( T_e \) in \( y \) results in \( y \)-periodic thermionic current. In Figure 2 a we have plotted normalized thermionic current, \( I/T_e^2 \), as a function of \( y \) and \( \theta \) for \( \phi/T_e = 30, ve^2A^2/(4m\omega^2\alpha_x^2\chi_e T_0) = 1, 2k \omega / \omega = 1 \mu m, \omega / \omega = 3, \ \varepsilon = 2, \varepsilon = -7 \).

The heated electrons impart energy to the lattice at the rate \( \hbar \omega \nu \nu' n_e \) per unit volume, where \( \hbar \omega \nu \) is the energy of an optical phonon, \( \nu' \) is the electron–optical phonon collision frequency and \( n_e \) is electron density. The lattice temperature rises at the rate

\[
\rho_T e I = \hbar \omega \nu \nu' n_e - \rho_T c \nu' / 4,
\]

where \( \rho_T \) is the lattice density, \( S \) is the specific heat of the lattice and \( \nu \) is the average thermal speed of atoms. \( \nu' \) is a strong function of electron temperature. As \( T_e \) reaches the melting point, the high temperature portion of the material melts and evaporates at the rate, \( n_e = n_0 e / 4 \), where \( n_0 \) is the number of atoms per unit volume. We have solved eq. (10) numerically and shown the variation of time to attain the melting point for aluminum (933 K) with \( \theta \) and \( y \) dimensions in Figure 2 b. The typical laser parameters for Al turn out to be \( \lambda \sim 1.06 \mu m, 10^{10} \ W/cm^2 \) (Nd: YAG laser). The plot shows a periodic behaviour, thereby indicating the formation of a periodic structure. The achievable periodicities are 600, 700 and 100 nm for \( \theta = 30, 45 \) and 60° respectively. On employing a single SPW, the \( \theta \) and \( y \) variations of temperature are lost. However, the time required by a single SPW to reach the melting point is of the same order as that of the proposed scheme. Thus the process could be employed to create periodic dot and grating structures, as it has been found that mode-converted SPW is more effective in causing heating and emission of electrons when the laser spot size is larger by an order of magnitude or more than the laser wavelength\(^5\). The periodic density thus created may also lead to diffraction and parametric excitation of side band.

**Figure 2.** Variation of (a) normalized thermionic current and (b) time to reach ablation temperature along the metal surface (y) with angle \( \theta \).
SPW, thereby weakening laser–SPW coupling. The two surface waves can be launched by employing the attenuated total reflection configuration, in which the electromagnetic wave is launched onto the prism–metal interface at an angle such that the component of propagation constant of the electromagnetic wave in the glass along the interface equals the propagation constant of the metal.

The process could go over to a parametric one, where initially a weak SPW is excited by surface roughness induced scattering from the incident field; the spatial modulation of the optical intensity resulting from the interference between the incident wave and the SPW can provide the growth of a periodic structure which increases the scattering into the SPW. Coupling to SPWs has shown to result in substantial field enhancement in the vicinity of a metal/dielectric interface. This could also serve as a diagnostic tool for various linear and nonlinear optical spectroscopic studies of the interface.

ACKNOWLEDGEMENTS. This work was supported by University Grants Commission, New Delhi under major research project.

Received 5 September 2003; revised accepted 28 January 2004

Field measurements of sub-micron aerosol concentration during cold season in India

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Sub-micron particle size distribution and temperature were measured at six levels immediately above the ground surface during 8–16 December 1997 and 24–28 December 1998. Diurnal observations were made at every three-hour interval at all the levels. Continuous measurements of aerosol concentration were made from 0300 to 1000 h at 1 m level. During this period, particle concentration decreases from 0300 h, attains a minimum value between 0600 and 0700 h, and then maximum at 0900 h. Particles 0.075 μm show systematic variation in concentration, whereas particles < 0.075 μm show large fluctuations with time during 0300 to 1000 h. Concentration of particles of sizes 0.075–0.75 μm shows a minimum at 15-cm level where the temperature is maximum. However, particles of size 0.013 μm undergo Brownian diffusion and thus do not show any trend with temperature. The phenomena of thermophoresis and fog scavenging are discussed in terms of these results.

Thermophoresis is the motion of particles caused by a kind of thermally induced force, which arises from the non-uniform heating of particles due to temperature gradients in the suspending gas. Consider a particle suspended in the fluid with the temperature gradient. It is well known that gas molecules in a high temperature area have higher.

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