PROBING LOCAL OPTICAL PROPERTIES USING FAST ELECTRONS

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Transmission electron microscopes allow studying optical properties with spatial resolution way below one nanometer and energy resolution better than a fraction of an eV. This makes it possible to actually map the spatial strength of low-energy, collective excitations in complex nanostructures ranging from finite distributions of nanometer-size objects to photonic crystals and other types extended objects. This talk will survey the status of both theory and experiment in low-energy electron energy loss spectroscopy (EELS). A review of recent advancement in experimental techniques and theoretical analysis will be presented and opportunities for applications will be discussed. In particular, the following examples will be described in detail: (1) the excitation and structure of plasmon modes in complex metallic nanostructures [1]; (2) EELS in carbon structures (fullerenes and nanotubes); (3) cathodoluminescence as a way to spatially visualize collective modes in nanostructures; (4) Cherenkov radiation in bounded objects; and (5) Cherenkov radiation in photonic crystals as a way to probe their photonic band structures locally [2] (see Fig. 1).

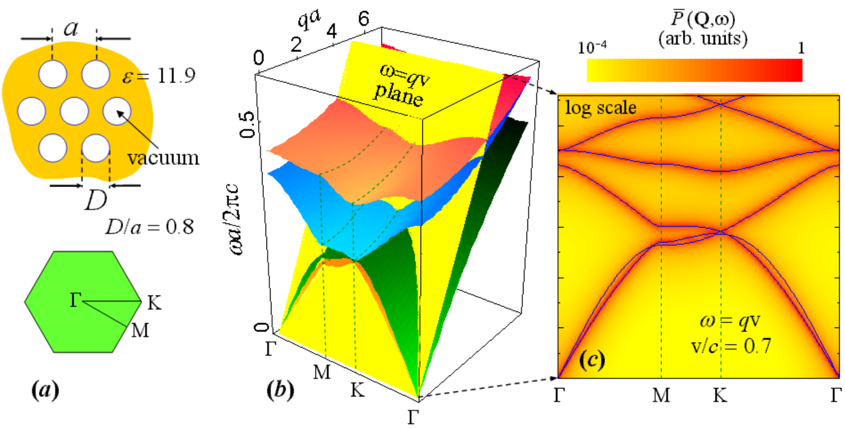

Figure 1. **(a)** 2D Si photonic crystal structure (upper part) and corresponding first Brillouin zone. **(b)** Photonic band structure for a diameter to lattice constant ratio D/a=0.8. Only the four lowest bands are shown for clarity. q is the momemtum along the holes **(c)** Intersection of these bands with the ω=qv plane (i.e., the energy-momentum region where a charge moving parallel to the holes can couple to the crystal) for v=0.7 c (curves). The underlying density plot (in log scale) shows the calculated EELS probability averaged over electron impact parameters, and resolved in both photon frequency ω and momentum transfer perpendicular to the cylinders axes, **Q**.

[1] F. J. García de Abajo and A. Howie, Phys. Rev. Lett. **80**, 5180 (1998).
[2] F. J. García de Abajo, N. Zabala, A. Rivacoba, A. G. Pattantyus-Abraham, M. O. Wolf, and P. M. Echenique, Phys. Rev. Lett. **91**, 143902 (2003).