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ASPECTS OF THE OPTICAL PROPERTIES OF QUENCH CONDENSED METAL FILMS

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Abstract. — We have studied the optical properties of several quench condensed noble and polyvalent metals. The effect of quench condensation varied from metal to metal. The spectrum of gallium for example showed an ideal Drude behaviour which is a drastic change from the strong parallel band absorption peaks for both metals. These peaks were strongly reduced in the quench condensed films, but residual interband absorption was seen [3]. Beryllium behaved quite differently from these metals when quench condensed. It has the highest Debye temperature of all metals, 1 440 K, and forms amorphous films when evaporated onto substrates at 10 K. The optical absorption spectra however, in the crystalline and amorphous states were very similar indeed [4]. This must imply that the gross features of the bandstructure in the two instances were similar and we concluded that for beryllium, in contrast to the other metals that we have studied, the dominating factor in determining the electron states is the short range atomic order.

Electronic properties related to states near the Fermi surface in quench condensed metal films have been studied extensively over the last twenty years, while relatively little has been done to study the properties far away from the Fermi energy. Optical properties constitute one of the simplest and most efficient means of providing such information. We have therefore studied the optical properties of a number of quench condensed pure metal films.

We studied thick opaque films evaporated in UHV onto sapphire substrates at 10 K and 80 K. The optical properties were studied in situ in the energy range $0.5 \leq \hbar \omega \leq 5.5$ eV by an ellipsometric technique.

We have focused our attention on the polyvalent metals. The spectrum of these is often characterized by strong parallel band absorption peaks. Such peaks are expected to be sensitive to crystalline disorder and this was born out by our observations. In the case of gallium, which forms amorphous films when evaporated onto substrates at 10 K, we found a true Drude like spectrum [1] with an electron mean free path of about 15 Å.

Aluminium forms microcrystalline films with a grain diameter of typically 50 Å when quench condensed. The strong parallel band absorption peak characterizing the crystalline aluminium spectrum, was absent in the microcrystalline films [2]. The spectrum showed a monotonic decrease towards higher energies. It did not satisfy the Drude equations, but an excellent description of the spectrum could be obtained by a theoretical model where we assumed that the films consisted of two phases-grains and grain boundaries, and that both constituents had a Drude like response but with different lifetimes and possibly different frequencies [3]. This is surprising, 50 Å grains contain such a large number of atoms that one would expect some residual band structure effect.

We have also studied quench condensed films of magnesium and lead. Both these metals form microcrystalline films with grain diameters somewhat larger than for aluminium. The crystalline spectra show strong parallel band absorption peaks for both metals. These peaks were strongly reduced in the quench condensed films, but residual interband absorption was seen [3].
References


[3] BERNLAND, L. G., HUNDERI, O. and MYERS, H. P., Chalmers