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HIGH-RESOLUTION MAGNETIC IMAGING AND
INVESTIGATIONS OF THIN-FILM MAGNETISM WITH
SPIN-POLARIZED ELECTRON, ION AND ATOM PROBES

Progress Report

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G. K. Walters and F. B. Dunning

Rice University, Houston, TX 77005

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HIGH-RESOLUTION MAGNETIC IMAGING AND INVESTIGATIONS OF THIN-FILM MAGNETISM WITH SPIN- POLARIZED ELECTRON, ION AND ATOM PROBES

Research during the current grant year has focused on:

- (1) Completion of the Spin-Polarized Electron Energy Loss Spectroscopy (SPEELS) research program.
- (2) Design of an improved and much more intense metastable atom source that can also be converted to a Rydberg atom beam, for continuing studies utilizing Spin-Polarized Metastable (Atom) Deexcitation Spectroscopy (SPMDS), and to initiate new investigations of interactions of Rydberg atoms with surfaces.
- (3) Development of a spin-polarized He^+ ion source for studies of ion-surface interaction dynamics and epitaxially grown magnetic films utilizing Spin-Polarized Ion Neutralization Spectroscopy (SPINS).

I. SPEELS

In these experiments, a beam of spin-polarized electrons is directed at the target surface and the energy- and angle-dependence of the spin polarization of electrons leaving the surface is measured for primary beam energies of ~15 to 150eV.

The investigation, begun in FY94, of energy loss dynamics in electron-surface collisions has recently been completed, and a model has been developed for interpreting the

data in terms of relative contributions from plasmon- and electron-hole pair excitation as functions of both energy loss and scattering angle. A manuscript is in preparation.

We have also participated, along with a number of other spin-sensitive spectroscopy laboratories world-wide, in an interlaboratory study sponsored by the Stanford Linear Acceleration Center (SLAC) directed toward obtaining general agreement on the spin-polarization and quantum efficiency of electron beams based on SLAC-supplied epitaxially-grown GaAs photocathodes. These cathodes will become secondary standards available to interested laboratories for calibrating Mott polarimeters and GaAs polarized electron source performance.

II. SPMDS AND RYDBERG ATOM-SURFACE INTERACTIONS

The SPEELS apparatus will be overhauled and reconfigured this summer to accommodate a new metastable atom source derived from an intense dc electrical discharge. The beam intensity is expected to be at least an order of magnitude greater than that of the present source, and will enable SPMDS experiments on epitaxially grown ultra-thin ferromagnetic films.

The design also includes provision for production of Rydberg states of argon by laser excitation of an Ar (3P_2) metastable atom beam, which will be used to explore the physical characteristics of Rydberg atoms when perturbed by a nearby surface, and to examine electron tunneling at surfaces which is the basis of many electron-based surface spectroscopies of practical importance. Details were provided in the original proposal for this grant.

III. SPINS

With future SPMDS experiments to be undertaken in the modified SPEELS apparatus, as described in Section II above, the metastable atom source on the original SPMDS apparatus is presently being replaced by a spin-polarized He^+ ion beam that has

been designed, constructed and tested during the present grant year. The source will deliver a nanoampere or more of He^+ ions to target surfaces, with energy variable over the range $\sim 3\text{eV}$ - 1000eV , and with energy spread $\sim 3\text{eV}$. Focussing optics and beam scanning capabilities will be added later to enable highly surface-specific magnetic imaging of epitaxially-grown and sputter-deposited thin films.