High-Density Plasma Source

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We acquired and evaluated a new type of high-density plasma source for sputter deposition. The plasma "beam" used for sputtering is generated remotely, and its path to the target is defined by the orthogonal locations of two electromagnets: one at the orifice of the plasma tube and the other just beneath the target plane. An example configuration of a vacuum chamber with the plasma source for sputter deposition is shown in Fig. 1.

One advantage of this source is that the high plasma density lends itself to higher deposition rates, an important parameter in the production of metal oxides. Another, more subtle advantage is the ability to independently control the deposition rate and the target bias voltage. This adds another means to control oxide properties that are not available in typical magnetron sputter sources. The electromagnets enhance the electron mean free path in the space between the plasma orifice and the target. When the RF power is applied to the coils around the plasma source, the argon atoms in this region are ionized. The current to the orifice electromagnet is kept constant, while the current to the steering electromagnet is adjusted to steer the high-density plasma beam onto the target. The target bias potential accelerates the argon atoms across the dark-space sheath and sputters the target material.

Project Goals

We performed a study to determine the deposition rate dependency of the high-density plasma source on deviations from the optimal geometric configuration. The study was performed during the reactive deposition of niobium oxide. The effect on deposition rate was determined by moving the plasma source away from the target in one direction, and by moving the target assembly away in an orthogonal direction. Deposition parameters were established to produce nonabsorbing niobium oxide films of about 100-nm and 350-nm thicknesses. The quality of the niobium oxide films was studied spectroscopically, ellipsometrically, and stoichiometrically.

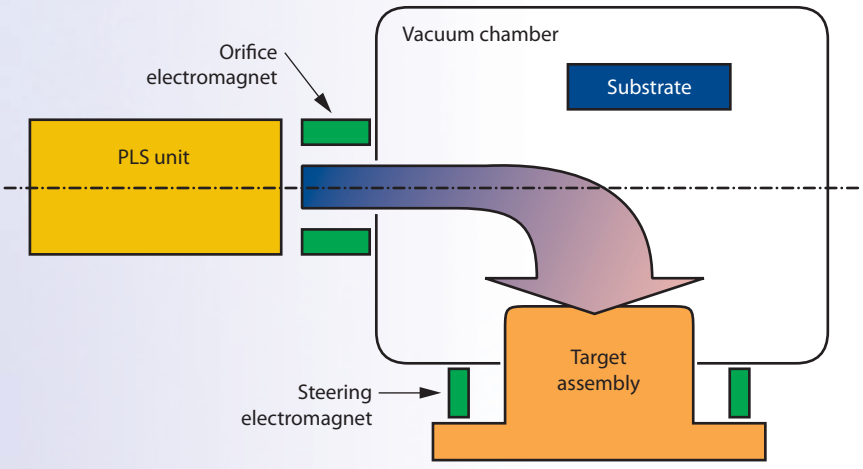

Figure 1. High-density plasma source configuration for sputter deposition.

Relevance to LLNL Mission

Over the last several years, LLNL has been working towards miniaturization and survivability of fireset components for integration onto a single substrate for weapons applications. Nanostructure multilayer technology (NML) is a key factor in the component work. Improvements have been made toward increasing the capacitance, energy density, and dielectric strength of our NML capacitors by testing different materials and sputtering processes.

FY2006 Accomplishments and Results

The high-density plasma source was acquired, installed in the Vacuum Test Lab, and its performance was evaluated. Figure 2 is an image of the source in operation. The deposition rate characteristics of the high-density plasma source were evaluated. Reactive sputtering with a high-density plasma source of niobium in the presence of an oxygen partial pressure produced stoichiometric niobium pentoxide, which is an important material for programmatic missions.

Related References

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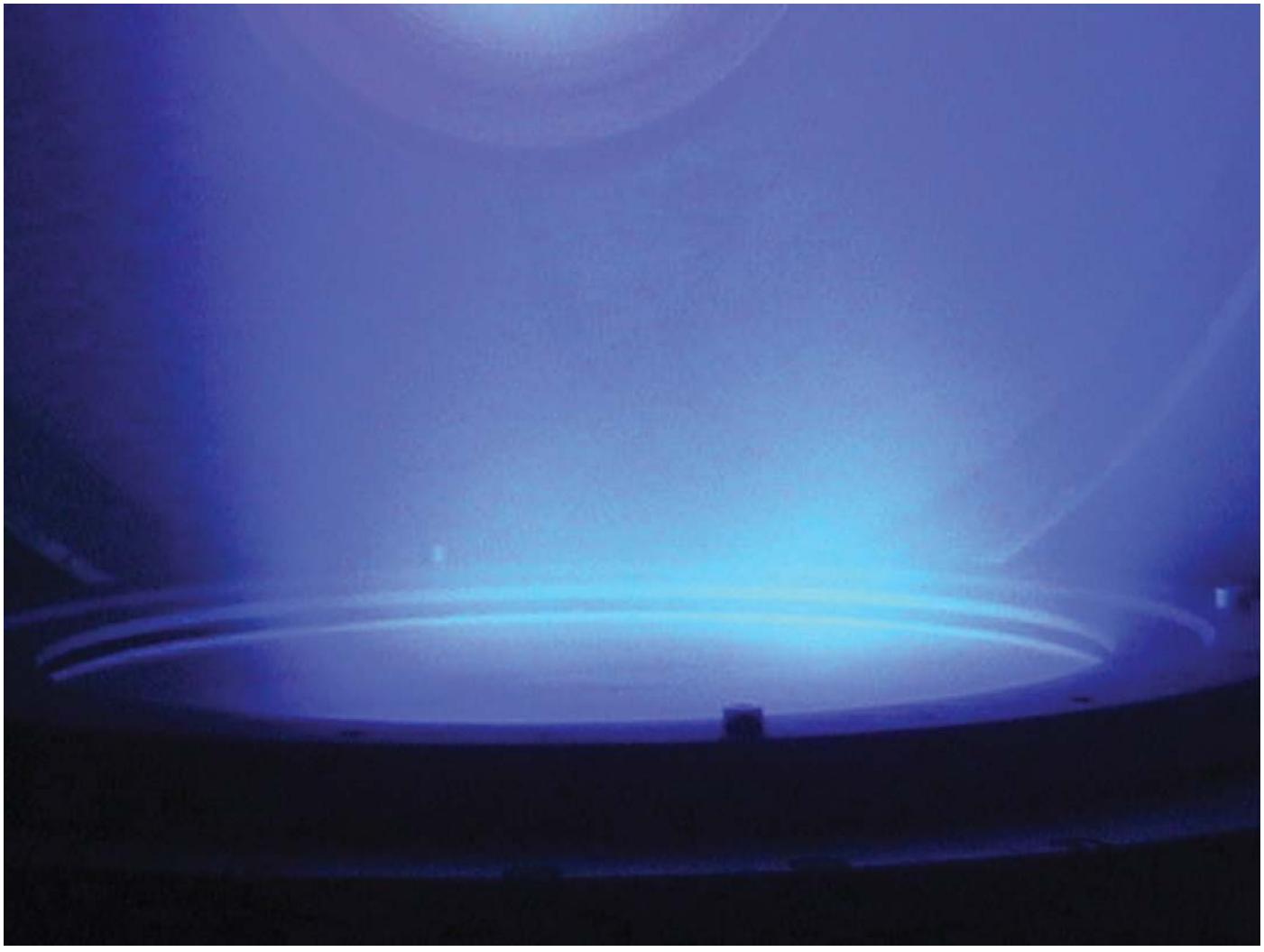

Figure 2. High-density plasma source in operation.