

Deposition of Gold Films as a Sample Surface Coating for Magnetic Resonance Force Microscopy

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Principal Investigator(s): John Marohn

User(s): George Du Laney

Affiliation(s): Chemistry & Chemical Biology, Cornell University

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Contact: gdf9@cornell.edu, jam99@cornell.edu, grd44@cornell.edu

Website: <https://marohn.chem.cornell.edu/>

Primary CNF Tools Used: CVC SC4500 Odd-Hour E-beam evaporator

Abstract:

We employ e-beam evaporation of gold to prepare a surface noise-reducing coating for applications in magnetic resonance force microscopy. By transferring the deposited gold film from a sacrificial polymer to our samples of interest, we ensure we have a sample with the benefits of a gold coating while avoiding sample damage from direct exposure to e-beam evaporation.

Summary of Research:

Magnetic resonance force microscopy (MRFM) is a scanning-probe technique used to resolve the locations of nuclear and electronic spins using principles of magnetic resonance. To accomplish this, we bring an attonewton-sensitive magnet-tipped microcantilever in proximity to a spin-polarized sample. The sample's polarization is modulated and the resulting changes to the cantilever's vibrational amplitude and frequency are recorded as the signal. A challenge in MRFM is achieving an optimal cantilever-sample separation while avoiding surface noise-induced frequency fluctuations. It has been shown that applying a conductive layer over a polymer sample can reduce this surface noise. [1] Previous work has employed e-beam evaporated gold films to reduce surface noise in MRFM measurements. [2–4] Radical-doped polymer films which had gold directly e-beam evaporated onto them had a reduced electron spin resonance (ESR) signal due to a suspected “dead layer” within the sample from excess heating. [5] A novel film transfer approach was developed whereby the gold was e-beam evaporated onto a sacrificial layer and then transferred onto the sample obviated this issue, recovering a factor of 20 in enhancement was achieved. [6]

Despite this 20-fold enhancement, there is still a factor of 17 difference between experimental ESR-MRFM signal and predicted signal. As we adjust our experimental parameters to recover this remaining factor of 17, we

continue to use this gold laminate coating to reduce sample surface noise.

Figure 1 shows a representative gold-laminate sample prepared for MRFM. The vertical column in the center is 20 nm of e-beam-evaporated gold sitting atop a ~520 nm film of tempamine-doped polystyrene. The ensemble of films sits atop the centerline of a custom-made waveguide for delivering radiofrequency and microwave radiation to the polystyrene film. A strip of gold was achieved by masking the sacrificial substrate with Kapton tape during e-beam evaporation. Masking allows the preparation of gold films that are small enough to stay over the centerline without covering the tapered regions of the waveguide, which would make the waveguide very lossy. To transfer the gold to the polymer-coated waveguide, the strip is aligned to the centerline, pressed together, and then the sacrificial substrate is allowed to dissolve, leaving the gold laminated to the polymer-coated waveguide.

This procedure of predefining the shape of the gold and aligning to the waveguide before dissolving the sacrificial polymer marks an improvement over a previously used version of this procedure, whereby strips were cut with a razor from a gold film that spanned the substrate, the sacrificial polymer was dissolved in water. [6] The cut-out flecks of gold were left to float on the water's surface, and the waveguide was stamped onto the flecks, which had a tendency to laminate imperfectly or in an incorrect location on the waveguide. This new transfer procedure affords the user more control over gold positioning, and

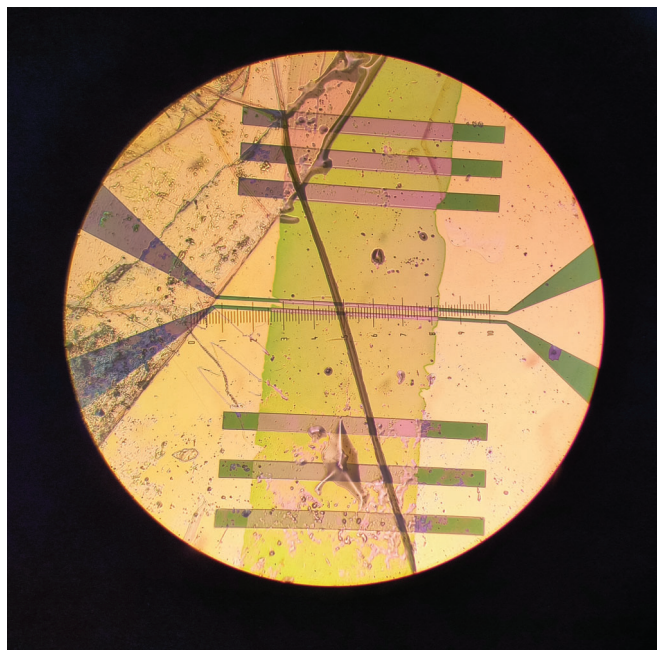


Figure 1: A 20 nm-thick strip of gold on a radical-doped polystyrene film, located over the centerline of a waveguide. Centerline dimensions are 10 μm by 500 μm . The roughness in the top left of the image is excess polystyrene film that did not laminate flatly during the transfer step. This image was taken using the Cornell Center for Materials Research's Olympus BH-2 optical microscope with IC20 objective. The graticule in the image is 500 μm across.

a single attempt is usually sufficient per waveguide.

Conclusions and Future Steps:

The implementation of e-beam evaporated gold films as a surface coating in our experiments continues to improve. Previous work developed a transfer procedure that avoided sample damage, and our latest procedure affords greater control over positioning the gold coating during the transfer. In the future, we may employ lithographically-defined masks to make precisely-defined regions of gold, but Kapton tape affords us the precision we need for the time being.

References:

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