Abstract:
The Cornell Nanoscale Facility (CNF) was used to fabricate arrays of gold nanowires (33 nm width) attached to macroscopic leads. These wires were then stressed by applying current until they failed under electromigration. With the devices fabricated at CNF, we were able to establish that (a) the electromigration process used to form the nanogap junctions is temperature-controlled, and (b) that good thermal contact of the wire to the substrate or to the electrodes is essential for controlling the electromigration to form uniform size nanogaps [1]. The ultimate goal is to use the CNF structures in future studies of single-molecule conduction across nanogap electrode pairs [2].

Summary:
Nanogap electrode structures such as those fabricated at CNF have been used by the principal investigators to investigate the electronic properties of a novel ferrocene-containing molecular wire [2]. Future investigations of other types of organometallic molecular wires are being planned; the fabrication of these structures en masse at CNF will greatly increase the ability to measure different molecular species rapidly.

In addition to the molecular electronics work, we have also studied the formation process of the nanogap junctions. An electrical feedback technique was developed to controllably break the junctions to form a gap with desired (tunnel) resistance (and presumably desired gap spacing). The feedback scheme was found to work only in the case that the nanowire was thermally well-coupled to either the bulk metal reservoirs (i.e. the wire was short) or a gate electrode (in the CNF devices the wire is on top of an aluminum gate electrode with thin alumina dielectric) [1]. It was also found that as the resistance of the junction increases, the junction voltage increases such that R is proportional to V squared; i.e. the power is roughly constant. This implies that the feedback process acts to control the temperature of the wire during electromigration [1].

References:
Figure 1:
Gold nanowire fabricated at Cornell Nanoscale Facility. This wire has undergone an electromigration process to form a nanogap; the gap is barely visible in this scanning electron micrograph.