Thermal Infrared Detection Using Antenna-Coupled Metal-Oxide-Metal Diode Detectors

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Antenna-coupled metal-oxide-metal diodes (ACMOMDs) can be used as detectors of long-wave, or thermal[1], infrared radiation. The devices consist of two main components: an antenna and a nonlinear junction, in this case a metal-oxide-metal diode. An ACMOMD functions by the rectification of antenna currents by the nonlinear junction. They are designed to detect radiation at 10.6 µm for two reasons: humans emit most strongly at this wavelength in the infrared, and in addition it is desirable to work in the long range infrared atmospheric window, between 8 and 12 µm, where absorption is relatively low.

ACMOMDs are fabricated using a single electron beam lithography (EBL) step, followed by a double angle, or shadow, metal evaporation. By employing shadow evaporation and an intermediate oxidation step, the need to align multiple EBL steps is negated. Shadow evaporation through an electron beam resist was first utilized in the fabrication of nano-scale tunnel junctions[2] and later in single electron transistors[3], but this research is the first to apply this technology to detector fabrication. The device is shown in the electron micrograph in Figure 1.

The current-voltage characteristic of these devices can be tailored by material selection and by controlling the oxidation conditions for the oxide barrier formation. The output of the device, due to incident radiation, is the rectified current, which is a function of detector sensitivity. The sensitivity is calculated by dividing the negative of the second derivative of the I-V characteristic by the first derivative[4]. Figure 2 demonstrates the ability to tailor diode resistance, zero-bias sensitivity, and peak sensitivity for $Al/Al_2O_3/Pt$ ACMOMDs.

Specific detectivity (D*) is used as a figure of merit for optical and infrared detectors[5]. Using a 10.6 µm CO_2 laser, we have measured a D* of 1.277×10^5 $cm \cdot Hz^{1/2} \cdot W^{-1}$ for ambient oxidation $Al/Al_2O_3/Pt$ devices, higher than any other MOM-based infrared detector. We expect D* to increase for reduced resistance controlled-oxidation devices, which will be presented. In addition, noise equivalent power (NEP), which is the amount of radiant power collected by a detector that will produce a signal-to-noise ratio (SNR) of 1, will be presented as a function of diode resistance. The NEP of our ambient oxidation $Al/Al_2O_3/Pt$ devices is 24.8 nW, and the SNR is 490. These devices are frequency selective, offer full functionality without cooling, and feature a small pixel footprint.

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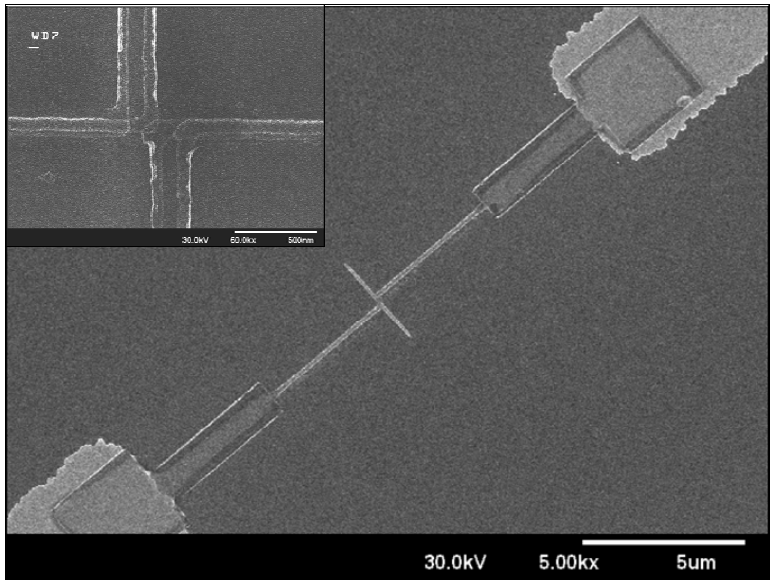

Figure 1: Scanning electron micrograph of an $Al/Al_2O_3/Pt$ ACMOMD. The antenna length is 3.1μm. The inset micrograph shows the 50 nm x 80 nm overlap area where the MOM diode is formed.

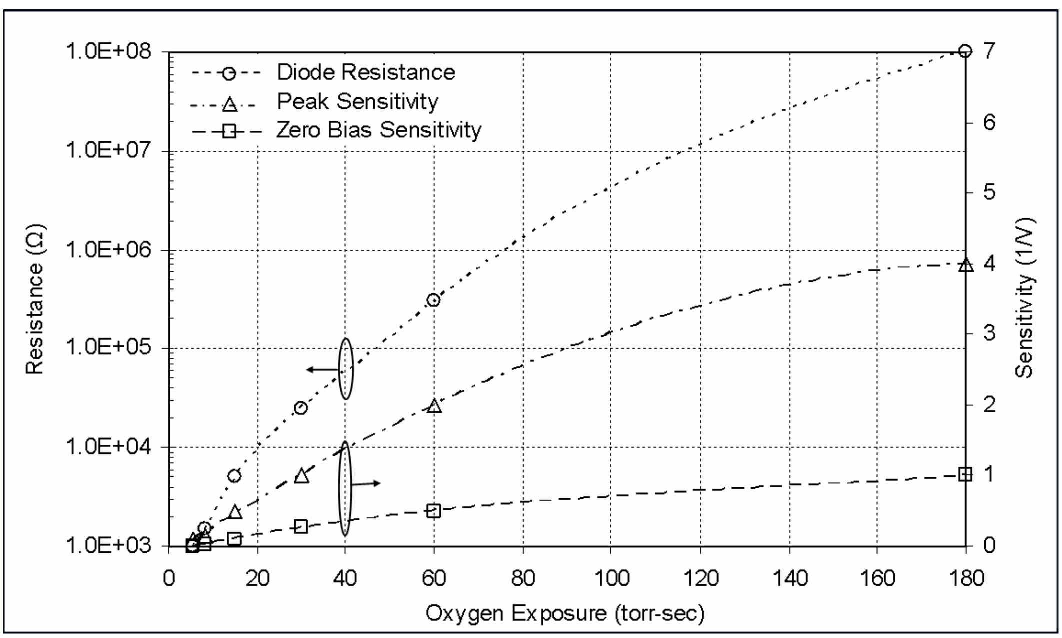

Figure 2: Diode parameters as a function of oxygen exposure for barrier formation in $Al/Al_2O_3/Pt$ ACMOMDs.