

# MULTIJUNCTION THERMAL CONVERTERS BY COMMERCIAL CMOS FABRICATION

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## Abstract

New multijunction thermal converters fabricated in a commercial CMOS foundry are described and the results of measurements of their ac-dc transfer characteristics are given.

## Introduction

New multijunction thermal converters (MJTCs) have been fabricated as microstructures in a commercial CMOS IC foundry such as offered by MOSIS† [1]. These new MJTCs are suitable for the measurement of ac voltage or current for frequencies ranging from audio to above 1 MHz using conventional thermal transfer techniques. The main innovation of this work is the ability to manufacture the device in such a commercial process. This allows easy integration with VLSI microcircuits using standard design libraries and leads to low-cost, foundry-independent products.

## Fabrication

It has been demonstrated that three dimensional microstructures can be realized in a routine, commercial CMOS process with an additional post-processing etch procedure [2,3]. This step is a "maskless" etch in ethylene diamine-pyrocatechol-water carried out after devices are received from the foundry. Special layout considerations and methods are used to create an open area that exposes the silicon surface to the etchant [4] producing suspended structures composed of layers of metal and polysilicon encapsulated in SiO<sub>2</sub>.

Thermal converters have recently been constructed using custom processing [5]. These devices used

additional layers of SiO<sub>2</sub>-Si<sub>3</sub>N<sub>4</sub>-SiO<sub>2</sub> to create suspended membranes by backside etching of Si and special metallization layers for the thermocouples. In our work, only the "standard" layers that are available in a routine commercial CMOS process are used. A similar approach was also demonstrated in [6]; however, a Si<sub>3</sub>N<sub>4</sub> layer was used in those structures which is not generally available at commercial CMOS foundries.

Figure 1 shows a picture of a typical device fabricated through the MOSIS service. The MJTC is a cantilever structure with a suspended, resistance heating element and thermocouple hot junctions located near the heater on the cantilever. The pit etched below is 150x150 μm in size. The heater structure is composed of a polysilicon resistor and the thermocouples are made of aluminum-polysilicon. These thermocouples have been shown to have a significant Seebeck effect [6].

## Results

Typical overall sensitivities of about 15 mV/mW have been measured in air. Some structures have been made with thermal time constants of 3 ms; however, other designs made with greater thermal mass have longer time constants. Approximate ac-dc differences of the new MJTCs, measured as voltage converters at 1 V, are -10 ppm at 10 kHz, -210 ppm at 100 kHz, and -260 ppm at 1 MHz. The dc reversal errors are generally a few tens of ppm.

These results indicate that these low-cost, foundry-fabricated MJTCs are very promising as RMS sensors for use in general instrumentation up to and beyond 1 MHz.

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# References

- [1] MOSIS is an acronym for MOS Implementation System. The MOSIS service is located at the University of Southern California's Information Sciences Institute, Marina del Ray, Calif.
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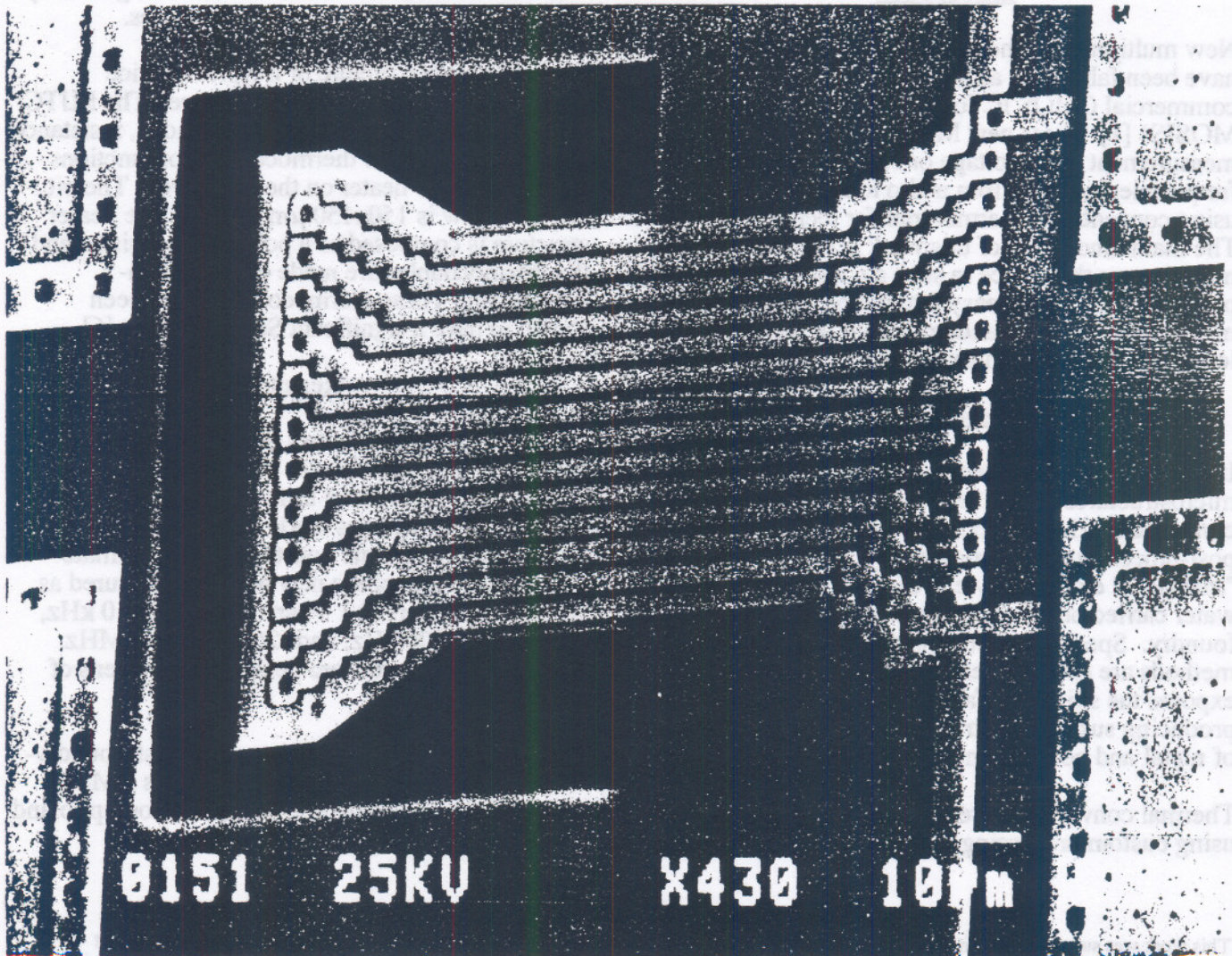


Fig. 1. An SEM micrograph of a multijunction thermal converter fabricated in a commercial CMOS process.