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Piezoresistive Membrane Hygrometers Based on IC Technology

Thomas Boltshauser, Andreas Häberli and Henry Baltes

Physical Electronics Laboratory, ETH Zurich, ETH Hoenggerberg,
CH-8093 Zurich, Switzerland

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We report integrated membrane humidity sensors fabricated by combining silicon micromachining and polyimide processing with standard IC technologies. The first principle is based on resonating membranes coated with thin polyimide films sensitive to relative humidity *RH*. We obtained frequency shifts of 55 Hz/%RH for a 300 μm by 300 μm CMOS (complementary metal-oxide-semiconductor) membrane at 370 kHz and 63 Hz/%RH for a 950 μm by 950 μm bipolar membrane at 150 kHz for a driving power of 48 mW. The second principle is inspired by the classical paper-tape hygrometer developed by Viviani in the 17th century. We translated this effect into industrial IC technology by covering a membrane with polyimide whose expansion is detected by piezoresistors embedded in a Wheatstone bridge yielding a sensitivity up to 0.44 mV/%RH. The membrane structures have been achieved by postprocessing, namely, anisotropic etching with KOH from the back of the wafer and polyimide deposition. A special process for cleaning and masking the unpolished back surface of the CMOS dies has been developed. An electrochemical etch stop at the p-n junction between the p-doped substrate and n-doped epitaxial layer on (100) silicon has been used for the bipolar devices.

1. Introduction

There is a strong demand for humidity sensors to be used, for instance, in the automotive industry, medical applications, and agriculture. Other important fields are air conditioning, building control, and meteorology. Users require inexpensive,