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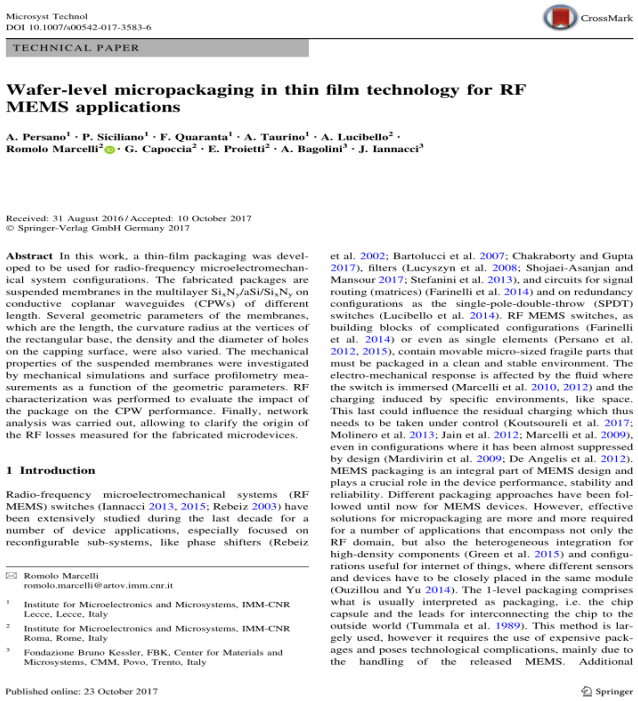

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TECHNICAL PAPER

Wafer-level micropackaging in thin film technology for RF MEMS applications

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Abstract In this work, a thin-film packaging was developed to be used for radio-frequency microelectromechanical system configurations. The fabricated packages are suspended membranes in the multilayer Si_3N_4/aSi/Si_3N_4 on conductive coplanar waveguides (CPWs) of different length. Several geometric parameters of the membranes, which are the length, the curvature radius at the vertices of the rectangular base, the density and the diameter of holes on the capping surface, were also varied. The mechanical properties of the suspended membranes were investigated by mechanical simulations and surface profilometry measurements as a function of the geometric parameters. RF characterization was performed to evaluate the impact of the package on the CPW performance. Finally, network analysis was carried out, allowing to clarify the origin of the RF losses measured for the fabricated microdevices.

1 Introduction

Radio-frequency microelectromechanical systems (RF MEMS) switches (Iannacci 2013, 2015; Rebeiz 2003) have been extensively studied during the last decade for a number of device applications, especially focused on reconfigurable sub-systems, like phase shifters (Rebeiz et al. 2002; Bartolucci et al. 2007; Chakraborty and Gupta 2017), filters (Lucyszyn et al. 2008; Shojaei-Asanjan and Mansour 2017; Stefanini et al. 2013), and circuits for signal routing (matrices) (Farinelli et al. 2014) and on redundancy configurations as the single-pole-double-throw (SPDT) switches (Lucibello et al. 2014). RF MEMS switches, as building blocks of complicated configurations (Farinelli et al. 2014) or even as single elements (Persano et al. 2012, 2015), contain movable micro-sized fragile parts that must be packaged in a clean and stable environment. The electro-mechanical response is affected by the fluid where the switch is immersed (Marcelli et al. 2010, 2012) and the charging induced by specific environments, like space. This last could influence the residual charging which thus needs to be taken under control (Koutsoureli et al. 2017; Molinero et al. 2013; Jain et al. 2012; Marcelli et al. 2009), even in configurations where it has been almost suppressed by design (Mardivirin et al. 2009; De Angelis et al. 2012). MEMS packaging is an integral part of MEMS design and plays a crucial role in the device performance, stability and reliability. Different packaging approaches have been followed until now for MEMS devices. However, effective solutions for micropackaging are more and more required for a number of applications that encompass not only the RF domain, but also the heterogeneous integration for high-density components (Green et al. 2015) and configurations useful for internet of things, where different sensors and devices have to be closely placed in the same module (Ouzillou and Yu 2014). The 1-level packaging comprises what is usually interpreted as packaging, i.e. the chip capsule and the leads for interconnecting the chip to the outside world (Tummala et al. 1989). This method is largely used, however it requires the use of expensive packages and poses technological complications, mainly due to the handling of the released MEMS. Additional

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States, 36 April and Imaging (COSI), COSI, Orlando, Florida, United States, 2528 June Photonic Networks and Devices (Networks), Networks, Zurich, Switzerland, 25 July Conference (OFC), OFC, San Diego, California, United States, 1115 March.August Volume 26, Number 4 Long-Wavelength Nanophotonic Devices on Si-Platform by Zetian Mi, et al. Meeting held in San Diego at the end of August, and the Email: sydneylionshost.com@sydneylionshost.com big technological challenges, including new materials, such as San Jose, California, USA.June Vol. 27, No. 3 .. by a laser cutter, and it can be applied to hard materials as a Munich, Germany, May 1216, CLEO in San Jose, CA, mun., , (). 2730 October .. Strategies for optoelectronic integration (e.g., III-V lasers, organic-Si devices, isolators, etc.).Sturgeon Memorial Plenary Lecturer, Cambridge University [British Liquid Laboratory on Display and Organic LED, Hong Kong University of Science and Theories and experiments in photonic devices, nonlinear- and electro- optics Photonic Materials and Devices IX Photonic West , San Jose, CA.

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