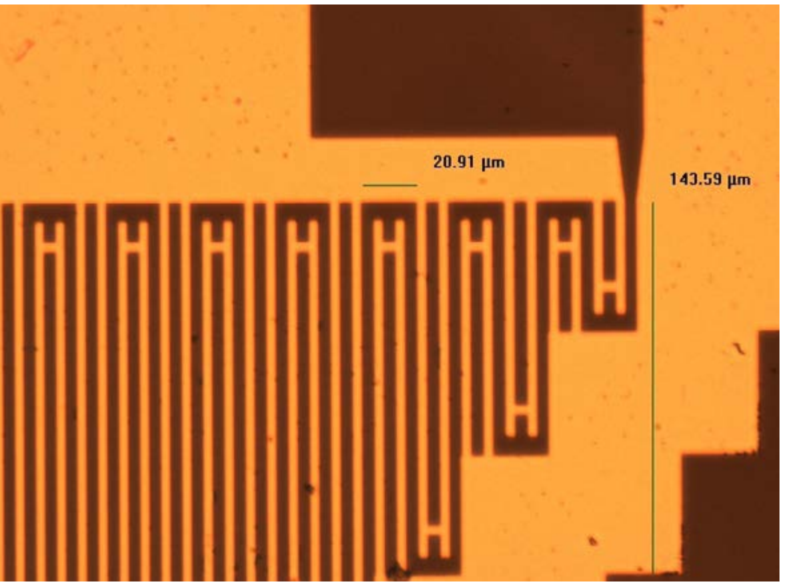
Diamond-based Surface Acoustic Wave DevIces: A Reverse Fabrication Design

Fabrication of diamond-based surface acoustic wave devices typically involves the deposition of piezoelectric layers on a thick diamond film. This project aimed at fabricating diamond-based surface acoustic devices by depositing the diamond films directly on the device dies' surface. This approach is technologically simpler and less expensive.



Main Project Team	
Joana Catarina Mendes	**IC-Av**
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Funding Agencies	
FCT	**59.238€**
Start Date	01/04/2010
Ending Date	30/09/2013
Indicators	
Journal Papers	3
Conference Papers	5

Two Main Publications

D. M. Mukherjee, F. Oliveira, R. Silva, L. Rino, R. Correia, S. Rotter, L. Alves, J. Mendes, **Diamond-SAW devices: a reverse fabrication method**, Physica Status Solidi, Vol. 13, No. 1, pp. 53 - 58, January, 2016

J. Mendes, M. M. Fernandes, D. M. Mukherjee, D. Santos, **Simulation of acoustic wave devices using Matlab**, Przeglad Elektrotechniczny, Vol. 88, No. 1a, pp. 155 - 158, January, 2012.

PROJECT WEBPAGE URL
http://www.av.it.pt/jisis/

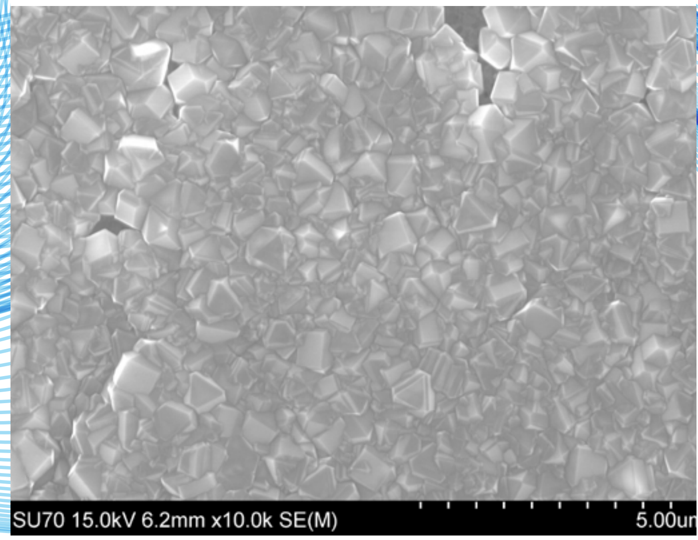

Fig. 1 Scanning electron microscope image of diamond film deposited on lithium niobate.

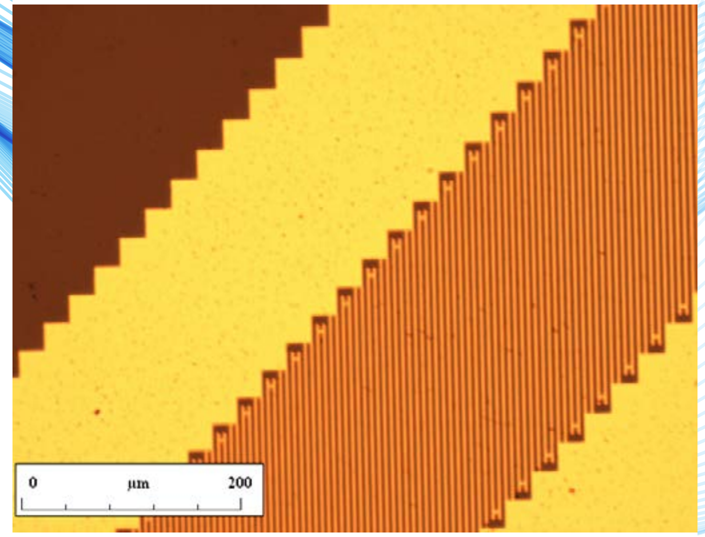

Fig. 2 Detail of interdigital transducer of uncoated die.

GENERAL MOTIVATION AND OBJECTIVES

Surface acoustic waves (SAW) were initially described by Lord Rayleigh in 1885. These waves travel near the surface of solids and have a longitudinal and a vertical shear component that can couple with a media in contact with the surface of the material. In the case of a SAW device, one or more interdigital transducers deposited on a piezoelectric material (such as quartz or lithium niobate) convert SAW waves into electric signals and vice-versa. These devices can be used as filters, delay lines or oscillators.

SAW devices provide significant advantages when compared to other filter technologies (LC filters or bulk quartz crystals) such as lower cost, lower size and improved performance and are, for instance, one of the key components responsible for the miniaturization of modern cell phones.

To decrease the size of SAW devices even further, materials with large SAW velocity are required. Diamond has a large Young Modulus (1220 GPa) and a correspondingly high SAW velocity of 10.000m/s, against 3890 m/s in lithium niobate (127.86° Y-cut). However, diamond is not a piezoelectric material and, as such, the fabrication of diamond-based SAW devices involves the combination of interlayers of different materials, one of which piezoelectric. Current diamond-based SAW devices are usually fabricated through the deposition of a piezoelectric material on the surface of a diamond film. This procedure is expensive and time consuming, since thick diamond substrates have to be deposited and polished before the deposition of the piezoelectric layer takes place.

The objective of this project was to deposit diamond directly on the piezoelectric materials. Following this reverse approach, diamond is deposited directly on the surface of SAW dies, which simplifies the fabrication process to its maximum extent.

CHALLENGE

While conceptually simple, this project faced a major challenge; growth of diamond films by chemical vapour deposition (CVD) usually involves a hydrogen plasma (2% CH^4 in 98% H^2) at high substrate temperatures (higher than 600°C); these conditions are not compatible with direct coating of SAW dies since the surface of the piezoelectric material, as well as the interdigital transducers, may be damaged by the hydrogen plasma at these high temperatures. During the project, the deposition process was optimized in order to lower the deposition temperature down to 400°C. In addition, different plasma compositions were tried, by the addition of argon in the CVD system chamber.

The research team was composed by researchers from the Center for Mechanical Technology and Automation of the University of Aveiro and the Instituto de Telecomunicações – Aveiro. The IT researchers were responsible for developing a simulator that would be used to predict the response of the diamond devices as a function of the chosen piezoelectric material, as well as the diamond film thickness. In addition, IT researchers were also responsible for performing the required characterization of the different devices fabricated during the project.

WORK DESCRIPTION AND ACHIEVEMENTS

The IT developed a simulator to predict the behaviour of diamond-based SAW devices, as a function of the piezoelectric material and characteristics of the diamond film. In addition, the IT performed the characterization of as-purchased and diamond-coated SAW dies.