



HAL
open science

Progress in process development of $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ thin films for uncooled THz bolometers

Thomas Quinten, Yoann Lechaux, Victor Pierron, Chantal Gunther, Laurence Méchin, Jean-Francois Lampin, Marc Faucher, Benjamin Walter, Bruno Guillet

► To cite this version:

Thomas Quinten, Yoann Lechaux, Victor Pierron, Chantal Gunther, Laurence Méchin, et al.. Progress in process development of $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ thin films for uncooled THz bolometers. 2023 48th International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz), Sep 2023, Montreal, Canada. pp.1-2, 10.1109/IRMMW-THz57677.2023.10299059 . hal-04277933

HAL Id: hal-04277933

<https://hal.science/hal-04277933v1>

Submitted on 21 Nov 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Progress in process development of $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ thin films for uncooled THz bolometers

T. Quinten¹, Y. Lechaux¹, V. Pierron¹, C. Gunther¹, L. Méchin¹, J.-F. Lampin², M. Faucher², B. Walter³ and B. Guillet¹

¹Normandie Univ, UNICAEN, ENSICAEN, CNRS, GREYC, 14000 Caen, France

²Institut d'Electronique de Microélectronique et de Nanotechnologie (IEMN), UMR CNRS 8520, Univ. Lille, Villeneuve d'Ascq, 59652 France

³Vmicro SAS, Avenue Poincaré, Villeneuve d'Ascq, 59650 France

Abstract— We present preliminary results of uncooled THz bolometers based on $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ thin films on SrTiO_3 buffered high resistivity silicon substrates. Fabrication improvements enable to obtain low contact resistance and the impedance measurements show that it is possible to minimize the impedance mismatch with an antenna.

I. INTRODUCTION

Antenna-coupled thermal sensors offer a unique choice for infrared detection applications. The antenna captures the incident radiation and can be designed to meet spectral, directional and polarization requirements [1]. The sensing element, in our case a bolometer, is located at the feed-point of the antenna. Previously, we have developed uncooled suspended $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ (LSMO) bolometer in the near infrared range since this material shows a strong variation of electrical resistivity as a function of temperature close to 300 K and a very low noise level [2-4] compared to other resistive materials such as semiconductors and other oxide-based materials. In this paper, we will present our progress in process development of uncooled antenna-coupled bolometers based on LSMO thin films on SrTiO_3 (STO) buffered high resistivity silicon substrates to reach THz domain.

II. SAMPLES

The 55nm-thick LSMO layers were deposited by Pulsed Laser Deposition (PLD) on STO buffered high-resistivity Si substrates ($5 \times 10 \text{ mm}^2$) to minimize electromagnetic losses. About 150nm-thick gold layers were deposited by ion beam deposition with KI etching or lift-off techniques to form contact pads. An Ion Beam Etching (IBE) was used to pattern LSMO layers. Examples of the test structures and the antenna-coupled bolometers are shown in Fig. 1.

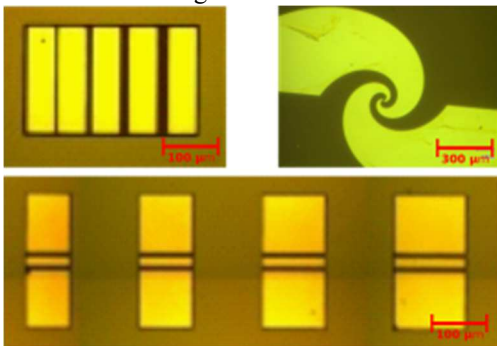


Fig. 1. Image of some test structures a) TLM Transmission Line Method b) CPW CoPlanar Waveguide designs and c) an antenna-coupled bolometer designs.

III. RESULTS

A. DC characterization

In order to determine the contact resistance value that can be problematic for impedance matching in antenna-coupled bolometer, DC electrical measurements using transmission line method (TLM) and four probes designs have been performed on different geometries and samples. Here we present the results on 2 typical LSMO/STO/Si samples: gold contact pads were defined by standard UV photolithography and chemical etching (sample A) or by lift-off process (sample B). Fig. 2 presents the electrical resistivity versus temperature characteristics of these unpatterned samples.

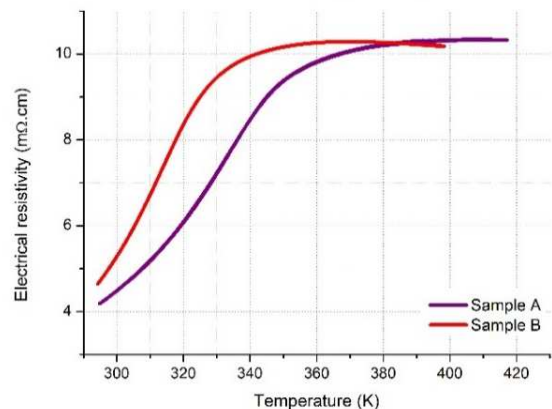


Fig. 2. Electrical resistivity versus temperature characteristics of the unpatterned 55 nm thick LSMO/STO/Si samples.

Using 4-probes and TLM designs, electrical resistivity and specific contact resistance at 300 K for the 2 samples are around few $\text{m}\Omega \cdot \text{cm}$ and few $10^{-4} \text{ Ohm} \cdot \text{cm}^2$. After an annealing at 320 °C during 30 min, specific contact resistance has reached $10^{-5} \text{ Ohm} \cdot \text{cm}^2$ for the sample B. It means that for a 50 Ω LSMO load ($10 \times 100 \mu\text{m}^2$), the DC contact resistance is about 5 Ohm. Moreover, previous measurements have shown that contact resistance tends to decrease with temperature [5].

B. RF characterization

RF measurements were made on different CoPlanar Waveguide (CPW) lines designed to have a characteristic impedance of 50 Ω without LSMO in the slots at different temperatures (300 K to 350 K) between 250 MHz and 50 GHz. Figure 3 shows impedance measurements (S_{11} , 1-port) of

120 μm -long 12 μm -large CPW structures (with LSMO load) measured with a vector network analyzer (VNA) with coplanar probes.

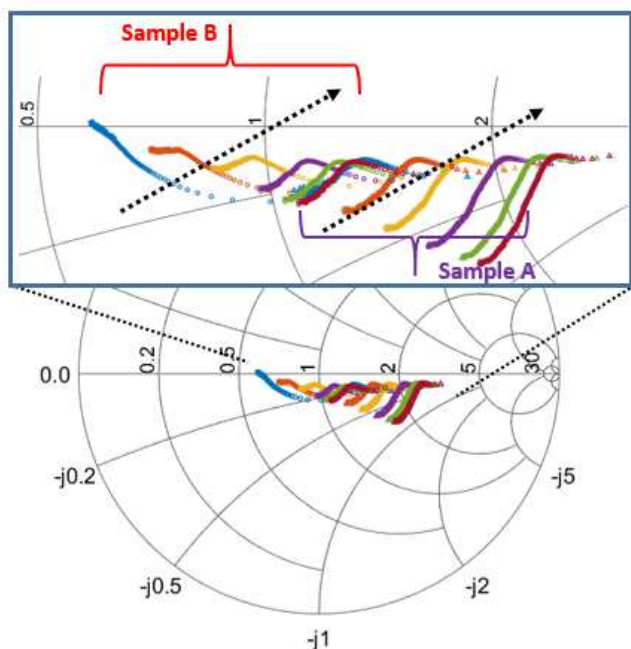


Fig. 3. Experimental results of impedance measurements (S11, 1-port) of CPW structures between 250 MHz and 50 GHz for the sample A (open triangle symbols) and sample B (open circle symbols) at different temperatures (blue 300 K; light brown 310 K; orange 320 K; purple 330 K; green 340 K and dark brown 350 K).

As expected the real part of the impedance shifts progressively to higher values as the temperature increase (the temperature coefficient of the electrical resistivity of LSMO is positive indeed). The sample B exhibits better performances probably due to the lower electrical contact resistance. For this geometry, the lowest reflection coefficient is obtained at 320 K. The impedance variation with the RF power and with the temperature have been also investigated in order to choose the optimal geometry and get a characteristic impedance close to 50 Ω at targeted frequency with a high sensitivity [6]. It seems thus possible to fabricate matched loads for mm-wave and THz bolometers. Further results will be shown at the conference.

REFERENCES

- [1] I. Codreanu and G. D. Boreman, "Integration of microbolometers with infrared microstrip antennas," *Infrared Phys. Technol.*, vol. 43, no. 6, pp. 335–344, Dec. 2002, doi: 10.1016/S1350-4495(02)00123-8.
- [2] L. Méchin, S. Wu, B. Guillet, P. Perna, C. Fur, S. Lebargy, C. Adamo, D.G. Schlom, J.M. Routoure, "Experimental evidence of correlation between 1/f noise level and metal-to-insulator transition temperature in epitaxial $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ thin films", *J. Phys. D: Appl. Phys. - Fast Track, Communication* 46 202001 (2013).
- [3] S. Liu, B. Guillet, C. Adamo, V.M. Nascimento, S. Lebargy, G. Brasse, F. Lemarié, J. Elfallah, D.G. Schlom, L. Mechin, "Free-standing $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ suspended micro-bridges on buffered silicon substrates showing undegraded low frequency noise properties", *J. Micromech. Microeng.*, 29, 065008 (2019)
- [4] V. M. Nascimento, L Méchin, S. Liu, A. Aryan, C. Adamo, D. G. Schlom, B. Guillet, "Electro-thermal and optical characterization of an uncooled suspended bolometer based on an epitaxial $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ film grown on CaTiO_3/Si ", *J. Phys. D: Appl. Phys.* 54 055301 (2021)
- [5] T. Quinten, Y. Lechaux, V. Pierron, J.-F. Lampin, C. Gunther, L. Méchin, M. Faucher, B. Walter, B. Guillet, "Impedance measurements in

$\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$ thin films for uncooled THz bolometers," in 2022 47th International Conference on Infrared, Millimeter and Terahertz Waves (IRmmw-THz), Aug. 2022, pp. 1–2.

[6] T. Quinten, J.-F. Lampin, E. Okada, V. Pierron, C. Gunther, L. Méchin, B. Walter, B. Guillet, "On-wafer RF high-power measurement with an LSMO load at 40 GHz", submitted to IRmmwTHz 2023