proceedings

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Abstract

Light-Emitting Silicon Nanowires (Si NWs) as a Novel Sensing Platform for SARS-CoV-2 Detection †

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† Presented at the XXXV EUROSENSORS Conference, Lecce, Italy, 10–13 September 2023.

Abstract: Silicon nanowires (Si NWs) are considered an outstanding material for several applications. We have realized quantum-confined and room-temperature luminescent Si NWs. These Si NWs exhibit a high-aspect ratio, and high sensitive and selective label-free detection has been demonstrated for proteins, small extracellular vesicles, and DNAs. The realization of a SARS-CoV-2 Si NW sensor able to detect a few virus copies and remain unaffected by the variant (such as Omicron) is reported, paving the way for new, cheap, optical label-free devices for the primary health care diagnosis with an industrially compatible approach.

Keywords: biosensors; silicon nanowires; light emission; SARS-CoV-2; optical sensor; Omicron

Citation: Leonardi, A.A.; Sciuto, E.L.; Lo Faro, M.J.; Fazio, B.; Rizzo, M.G.; Francioso, L.; Picca, R.A.; Nastasi, F.; Irrera, A.; Conoci, S. Light-Emitting Silicon Nanowires (Si NWs) as a Novel Sensing Platform for SARS-CoV-2 Detection. *Proceedings* **2024**, *97*, 159. https://doi.org/10.3390/proceedings2024097159

Academic Editor: Pietro Siciliano

Published: 7 April 2024

1. Introduction

A strong demand for low-cost portable sensors emerged during the SARS-CoV-2 emergency. Nucleic Acid Amplification Tests (NAAT) were highly reliable but required several hours of analysis, leading to days for the outcome. Lateral flow tests emerged as a fast analysis strategy, but their reliability was affected by the diffusion of different variants. The Omicron variant demonstrated a very challenging detection, with an impaired detection [1] pushing the demand for new low-cost, fast, and reliable sensors. By a Metal-Assisted Chemical Etching (MACE), we have fabricated room-temperature light-emitting Si NWs [2–4] with a high aspect ratio (>300), paving the way for a SARS-CoV-2 sensor able to detect a few copies of the virus and remain unaffected by the variant.

2. Materials and Methods

Si NWs were synthesized by MACE. A commercial Si wafer was used (Figure 1a), a few Au nanometers were evaporated (Figure 1b), and, after an HF/H_2O_2 etching, the Si NWs were finally obtained (Figure 1c). To limit the active area of the sensor increasing its reliability, the MACE synthesis was carried out after a photolithography

process that left only small circular areas (≈150 µm of radius) exposed, as seen in the SEM images in plan view (Figure 1d) and cross-section (Figure 1e). After the synthesis, the Si NWs were functionalized as follows (Figure 1f): (i) silane treatment by using (3-Glycidyloxypropyl)trimethoxysilane (GOPS); (ii) incubation with three ammino-terminated ss-DNA oligonucleotides complementary to the SARS-CoV-2; (iii) final hybridization by using the synthetic SARS-CoV-2 genome or the extracted Omicron variant.

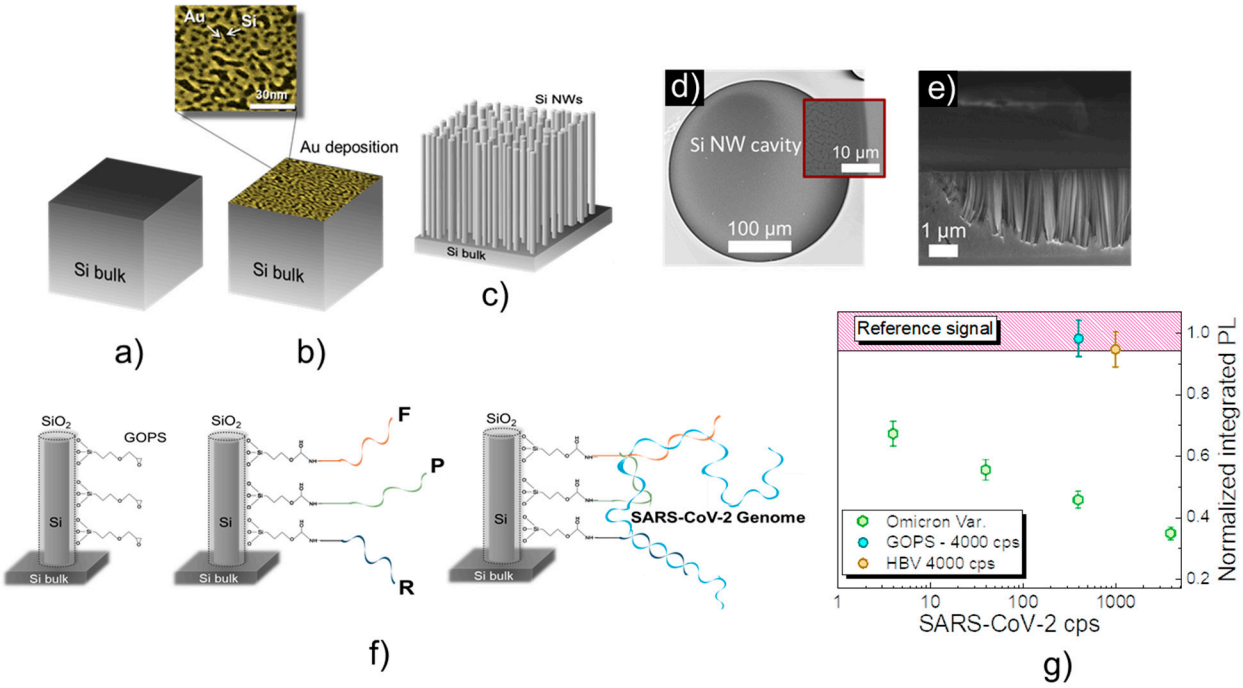

Figure 1. (**a**) Commercial Si wafer, (**b**) Au discontinuous layer, (**c**) Si NWs. SEM images Si NWs in the circular cavities in (**d**) plan view and (**e**) cross-section. (**f**) Functionalization protocol. (**g**) Calibration curve.

3. Discussion

The Si NW light-emission, normalized to the one obtained without any copies of RNA (reference signal), is reported as a function of the Omicron SARS-CoV-2 copies (cps) in Figure 1g (green hexagon). A total of 4 cps of the limit of detection is obtained without any amplification strategy and competitive with the NAAT standards. The Omicron detection shows the same signal of the SARS-CoV-2 clone, demonstrating the insensitiveness to the variant. The selectivity has been further tested by another target as Hepatitis B virus and without the oligonucleotide functionalization. In both cases, a negligible signal variation compared to the reference has been obtained. The detection of Omicron SARS-CoV-2 has been demonstrated with high selectivity and rapid detection. This result opens the route toward the realization of an industrially compatible silicon platform that can be used for the widespread and reliable detection of viruses.

Author Contributions: Conceptualization, A.I. and S.C.; methodology, A.I.; formal analysis, A.A.L.; investigation, A.A.L., E.L.S., M.J.L.F., B.F., L.F., M.G.R., F.N. and R.A.P.; resources, S.C.; data curation, A.A.L. and E.L.S.; writing—original draft preparation, A.A.L., E.L.S., A.I. and S.C.; writing—review and editing A.I. and S.C.; supervision, A.I. and S.C.; project funding acquisition, A.I. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The Institutional Review Board of the University of Messina approved this study under the protocol number 36/20 and in accordance with the tenets of the Declaration of Helsinki.

Informed Consent Statement: Informed consent was obtained from each patient. The research was carried out in accordance with the tenets of the Declaration of Helsinki and was approved by the Institutional Review Board of the University of Messina (protocol number 36/20).

Data Availability Statement: Dataset available on request from the authors.

Acknowledgments: F. Puntoriero is acknowledged for the useful discussion and help. I-PHOQS project CUP: B53C22001750006 is acknowledged.

Conflicts of Interest: The authors declare no conflicts of interest.

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