MEMS-BASED WAVEGUIDE SiO_2 FABRICATED BY RIE PROCESS FOR OPTICAL SENSING

V. H. Rodrigues*, J. R. Freitas, M. F. Silva, J. H. Correia

CMEMS – UMinho, University of Minho, 4800-058, Guimarães, Portugal
LABBELS – Associate Laboratory, Braga/Guimarães, Portugal
*a85402@alunos.uminho.pt

Introduction

- **Reactive Ion Etching (RIE)** is a **dry etching** technique and uses chemically reactive plasma to remove material deposited on wafers such as **silicon dioxide (SiO_2)** or **silicon nitride (SiN).**
- The proposed **planar waveguide design** (Fig. 1) is composed of a **SiO_2 layer** (high-refractive index) deposited on a **borosilicate glass substrate** (BR33) with approximately 80% of SiO_2 in its chemical composition (low-refractive index).
- Typically, the main materials for waveguides are SiO_2 and SiN and the RIE masking layer is aluminum-based (Al). An high refractive index of the SiO_2 layer can be tuned by controlling the deposition process parameters.

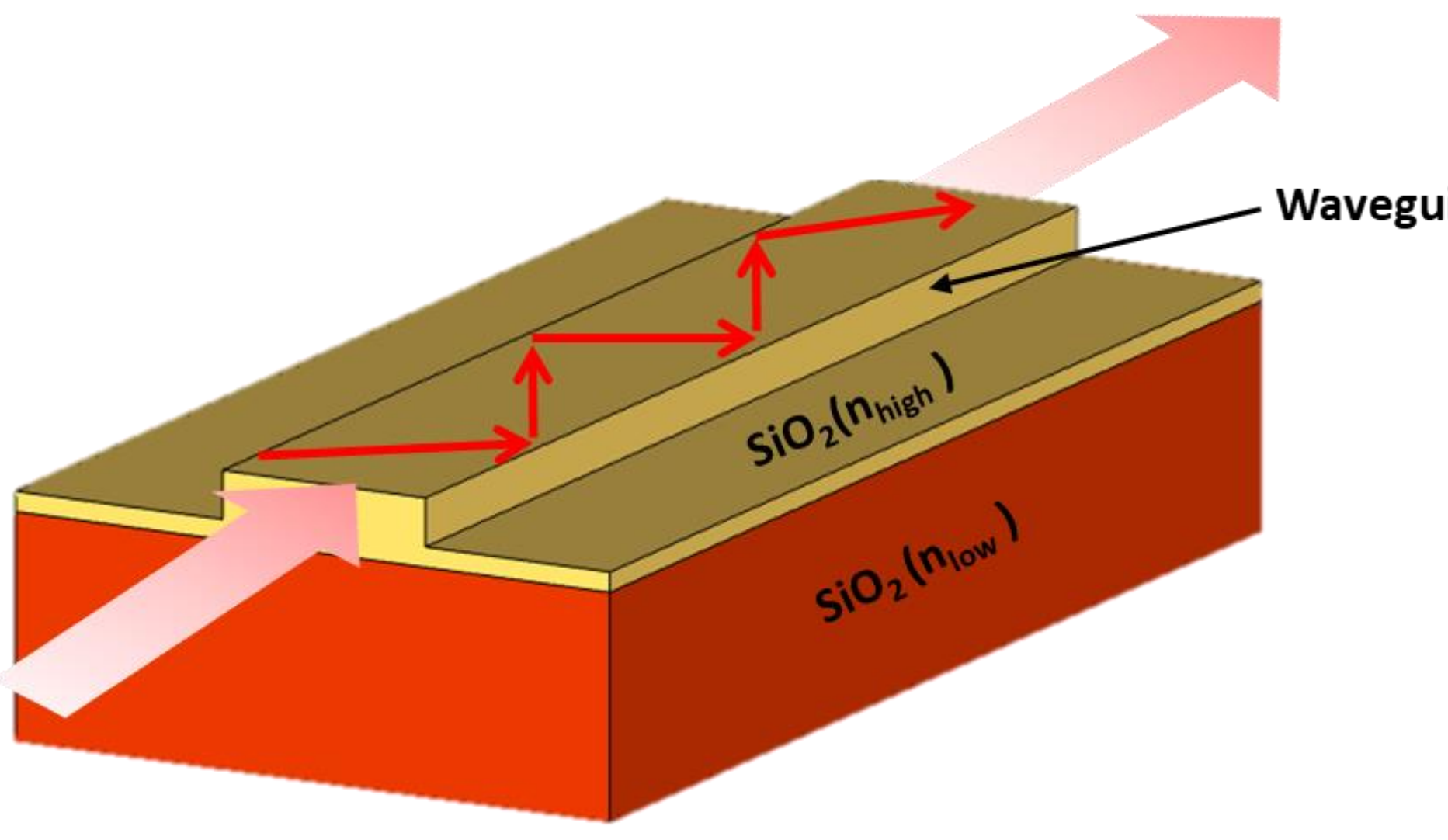

Fig. 1 – Example of a MEMS-based SiO_2 planar waveguide.

Methods

- A **200 nm thick SiO_2 layer** with a higher refractive index than the substrate (BR33) was deposited by means of RF magnetron sputtering from a SiO_2 target in argon(Ar)/N_2 plasma (ratio?).
- The following step was a **300 nm thick Al** RIE masking layer deposited by electron beam (e-beam) technique. The RIE masking layer was **patterned by photolithography** using a positive AZ 4562 photoresist and **exposed by DWL (Direct Write Laser)** .
- The exposed photoresist was **removed by AZ 351B developer** before pattering the Al masking layer in a **wet etching bath of phosphoric acid (H_3PO_4).**
- The unexposed AZ 4562 **was stripped in an AZ 100 remover** bath and the substate was ready to be etched in RIE with CF_4/O_2 plasma.
- Fig. 2 shows all the steps until the removal of the remaining Al and the waveguide result.

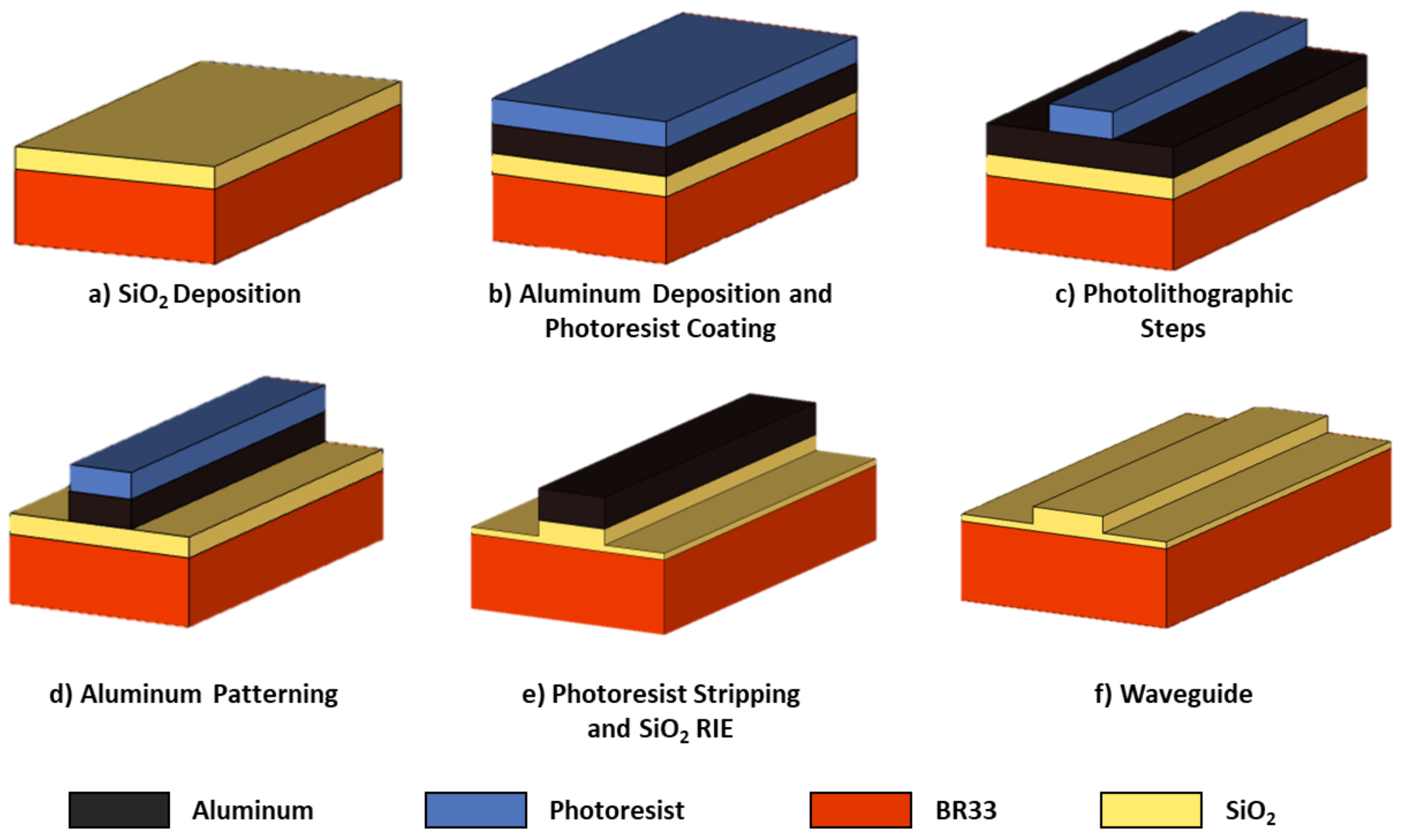

Fig. 2 – Representation of MEMS-based waveguides SiO_2 fabrication steps; a) SiO_2 deposition, b) Al layer deposition, c) Photolithography, d) Aluminum patterning, e) RIE of SiO_2 Layer, f) Waveguide result.

Results

- Fig. 3 shows the **etch rate results for BR33** (with 80% of SiO_2) etching with different RF power and different O_2 gas flow. The CF_4 etching gas flow was fixed to 40 mL/min. The **higher etch rate (400 nm/min)** was obtained at the **maximum RF power (200 W) and the O_2 flow of 40 mL/min.**
- The Al RIE masking and **SiO_2 layer adhesion to the BR33 substrate were good and reproducible** with the selected deposition techniques.
- The photolithographic process for patterning the Al using H_3PO_4 **was reliable even for dimensions smaller than 500 µm**.

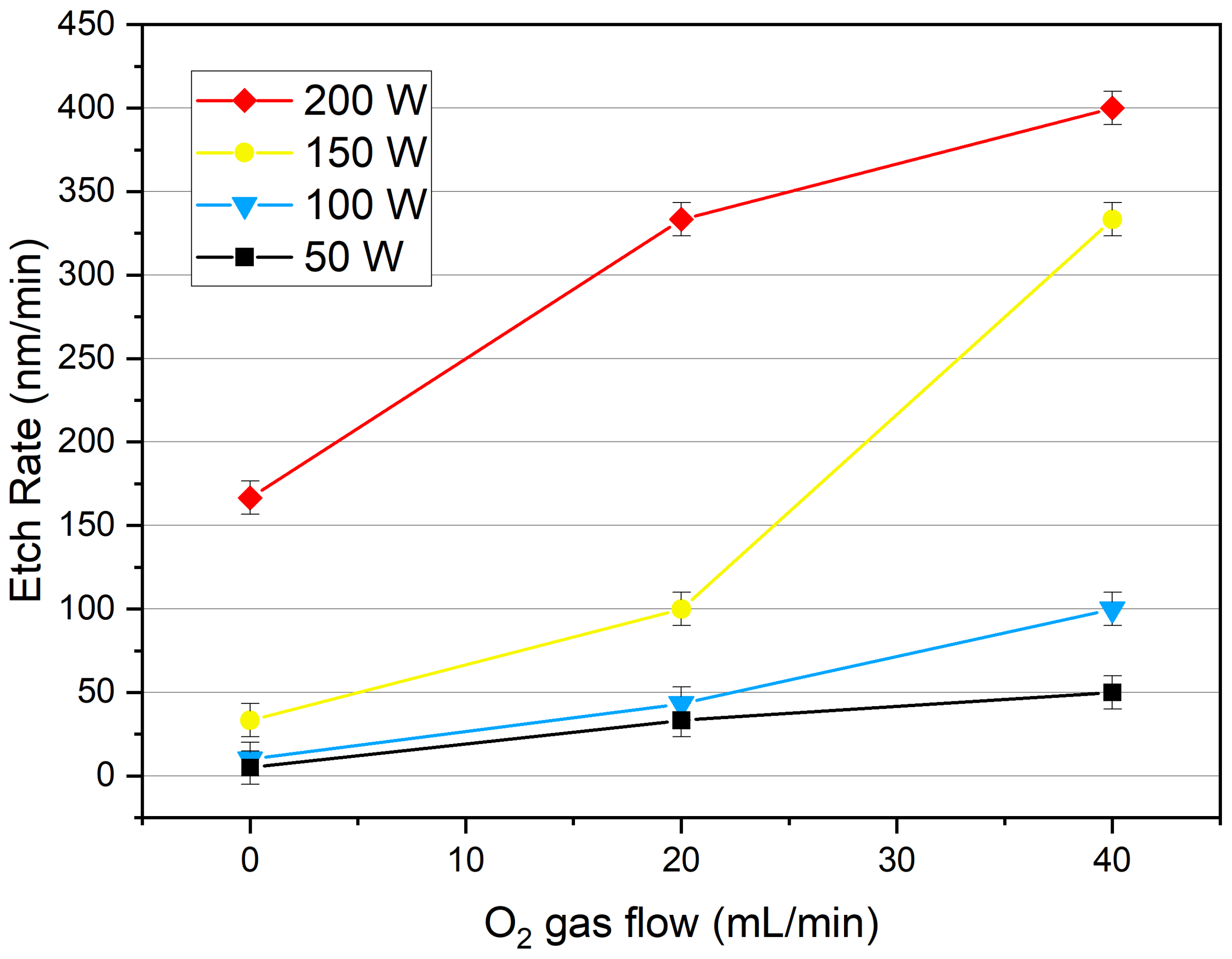

Fig. 3 – Etch rates for SiO_2 with 40 mL/min of CF_4 and different RF power from 50 to 200W at different O_2 gas flows.

Conclusions

- The experimental results prove that the use of RIE to fabricate the MEMS-based waveguide allows the wall and surface roughness precise control, high aspect ratio, and reproducibility.
- The **Al layer used as a mask was better than the photoresist mask** for high-power RIE system and long-etching time.
- The tests also prove that a higher RF power and O_2 gas flow **enhance the RIE etching process** enabling faster etches.
- Moreover, this work proves that **for larger shapes (> 500 µm) the etch rate was higher** by allowing better RIE gas penetration.

Universidade do Minho

UMINHO CMEMS
CENTER FOR MICROELECTROMECHANICAL SYSTEMS

LABBELS
ASSOCIATE LAB

FCT
Fundação
para a Ciência
e a Tecnologia

REPÚBLICA PORTUGUESA
CIÊNCIA, TECNOLOGIA
E ENSINO SUPERIOR

NORTE 2020
PROGRAMA OPERACIONAL REGIONAL DO NORTE

UNIÃO EUROPEIA
Fundo Social Europeu

Acknowledgments

This work was supported by: project MME reference 105399 and FCT with the project MPhotonBiopsy, PTDC/FIS-OTI/1259/2020, Infrastructures Micro&NanoFabs@PT, reference NORTE-01-0145-FEDER-022090, POR Norte, Portugal 2020, CMEMS-UMinho Strategic Project UIDB/04436/2020. J. R. Freitas thanks FCT for the Ph. D. grants 2020.07708.BD.