Porous vs. Magnetron RF Sputtering Of InP for Portable THz-TDS in Pharmaceutical and Medical Applications

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***Abstract* — We developed a combination of technology for deposition contacts/wires upon nanoporous InP thin film structures and RF sputtering InP films. Indium phosphide (InP) films were deposited onto glass substrate using RF magnetron sputtering by varying the substrate temperature (50–100°C), under constant argon pressure ($6.3 \cdot 10^{-3}$Bar) and RF power (100 W).**

***Index Terms* —InP film, RF sputtering, porous InP, THz antenna, THz-TDS.**

I. INTRODUCTION

The THz radiation can be produced by various methods (Free electron lasers, quantum cascade lasers, diode Gunn) and forms (continuous wave, pulsed, monochromatic, broadband) but suitable for our scope is broadband short pulse THz radiation generated in photoconductive antenna, see next figure.

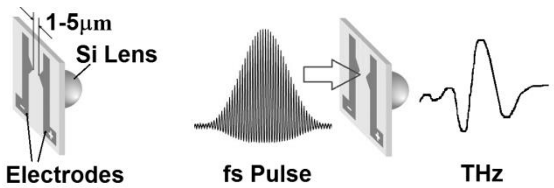

Fig.1 THz antenna

A short optical pulse (fs) generates charges between two electrodes coated on a semiconductor, charges that are accelerated due to electrical field applied between electrodes and recombines very rapidly (because structural defects) generating broad band THz pulses into the 0.1-5THz range.

Up to now low temperature grown GaAs was successfully used for this kind of photoconductive antennae (other materials and methods are less efficient).

II. . DEVICE FABRICATION

We found that nanoporous InP structure has much larger efficiency as a THz emitter and great potential as sensitive THz detector in comparison with bulk one. We developed the photoconductive antenna based on InP material. In reference [1] we have demonstrated that irradiating nanoporous membranes of (111) InP with heavy noble-gas ions enhances terahertz emission.

We developed a combination of technology for deposition contacts/wires upon nanoporous InP thin film structures, see the figures 2, 3. In this way we demonstrate the possibility of fabrication an array of antennas/detectors.

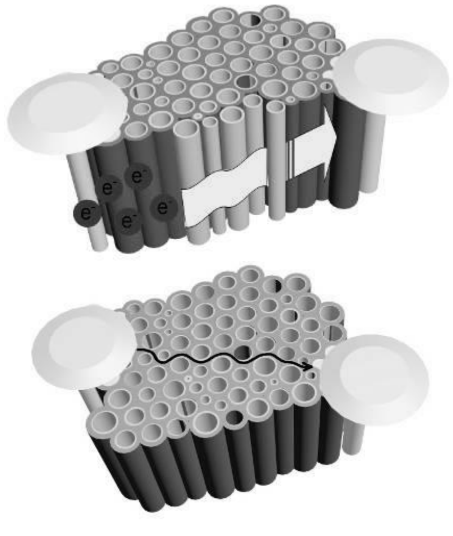

Fig 2. Carrier density of nanoporous InP is represented by grey color and with solid arrow/line show a conductive pathway.

The porous structure have been made using the [111]-oriented substrates of *n*-InP single crystals with 500 μm thickness and free electron concentration of $1.3x10^{18}$ cm^{-3}. The electrochemical etching was carried out in 5% HC1 aqueous solution in potentiostatic regime as described elsewhere [2].

Indium phosphide (InP) films were deposited onto glass substrate with the thickness of film around 100nm, using RF magnetron sputtering by varying the substrate temperature (50–100°C), under constant argon pressure and RF power (100 W).

A positive photoresist (PMMA) was used for both type of InP samples (porous and RF sputtering films) to configure Cr-Au pads and dipole antennas, obtained by liftoff method.

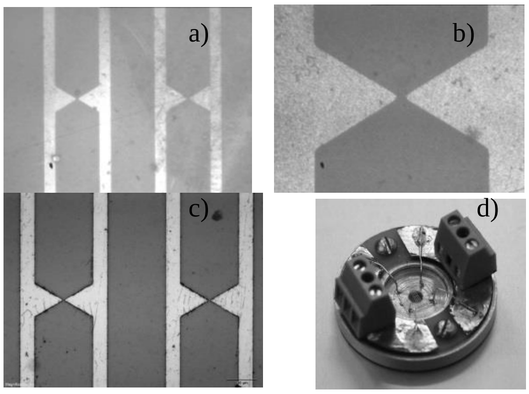

Fig. 3. Optical image of THz antenna on porous InP (schematic one in presented in Fig. 1) a,b), on InP film c), and mounted chip on 1" support d).

III. RESULTS

The elemental composition of the films was determined by electron dispersive X-ray analysis using EDX, which consist of ~40%atoms of P and ~60%atoms of In. This result is clearly shown in X-ray diffraction (Fig. 5) also by presenting the In peak in spectra. The inset is the Raman spectrum of the InP film, and we found a good correlation with literature [3, 4]

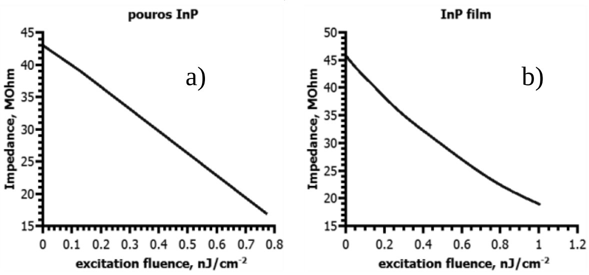

Fig 4. Impedance measurements at different excitation fluencies for porous InP a) and InP film b)

One can see, in figure 4, the impedance is changing at varying the incident beam excitation fluencies linearly for porous structures.

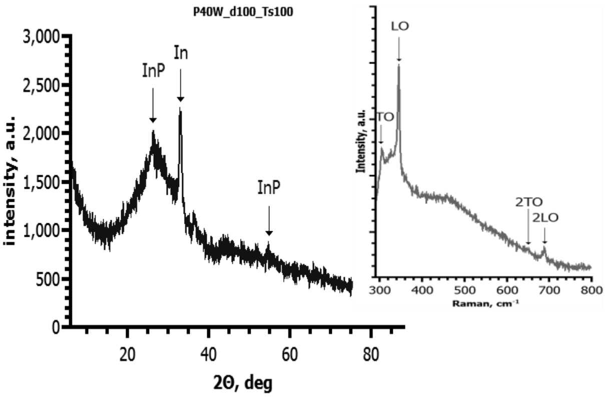

Fig. 5. XRD pattern for InP film, and the inset is its Raman spectrum

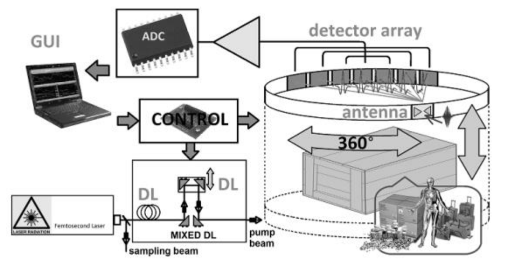

Fig. 6. A portable THz-TDS for pharmaceutical and medical applications

IV. CONCLUSIONS

Preliminary results shown that the impedance for both structures, porous structure and thin InP film, have variation at changing the incident beam excitation fluencies. This behaviour open possibility for further development and design the low cost THz antennas for portable THz-TDS scanners for pharmaceutical and medical applications.

ACKNOWLEDGEMENT

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