ELECTROSPINNIG PROCESS OF POLYMERIC FIBERS OVER LOW TEMPERATURE CO-FIRED CERAMICS

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ABSTRACT

The polymeric nanofibers are an interesting choice to be applied in sensor due its large application field. One application is in microfluidics devices as a template for metallic tubes. In this work the electrospinning process of polymeric fibers over patterned low temperature co-fired ceramics (LTCC) tapes was studied. It was observed that the fibers covers the holes that were patterned on an LTCC tape and also that the fibers tends to become aligned when they are electrospun over channels that are patterned on an LTCC tapes. This behavior may be attributed to alumina and glass particles in the LTCC structure.

INTRODUCTION

The electrostatic deposition of nanofibers has received a great interest in the last years due the large field of application. The nanofibers may be used as a catalyst and enzyme support or as a template for metallic nanotubes (1,2,3).

The nanotubes has a great number of interesting applications such as in nanofilters, in reaction nanochambers and fluidics nanomixers among others. In order to produce the nanofluidics devices the nanofibers must be electrospun aligned over the substrate (4,5,6). One of the most interesting substrate is the LTCC. The structures over LTCC will be done by CNC (computer numerical control).

Low Temperature Co-Fired Ceramics (LTCC) present one interesting possibility for making hybrid devices, because this material has compatibility with silicon and microelectronics processes, has good mechanical properties for fluidics applications, allows making three-dimensional structures, and can produce devices with high aspect ratios. LTCC is a glass-ceramic composite material, normally presented in the form of flexible tapes. The ceramic component of the material is usually alumina, but can contain other components. LTCC has a glass component, and an organic binder. After the sintering process, the organic binder is removed and the glass phase melts and solidifies joining the alumina grains, making the LTCC become hard (7).

Electrospinning is an ease and cost-effective process to obtain micro and nanofibers (1-3). The electrospinning process occurs when the electrical forces at the surface of a polymer solution overcome the surface tension and cause an electrically charged jet to be ejected. The solvent evaporates as the jet travels in air, leaving behind charged polymer fibers which lay themselves randomly on a collecting metallic electrode (8) Huang et al. (1) compare in detail this technique with others used to obtain polymeric fibers and, also, give extensive information about the use of different types of polymers with electrospinning. Recent works have demonstrated the feasibility of obtaining self-alignment of fibers and structures (normally pads for electric contact) previously defined on the substrate (5-8).

This work addresses the electrospinning of polymeric nanofiber over LTCC substrates in order to obtain hybrid microfluidics devices.

EXPERIMENTAL

The precursor solutions were prepared using 800 mg commercial polyacrylonitrile (PAN), and 10 ml of solvent (N, N dimethylformamide - DMF) in order to obtain concentration of 8% w/w. The solutions were stirred at 900 rpm during 24 hours, at room temperature before analysis or deposition.

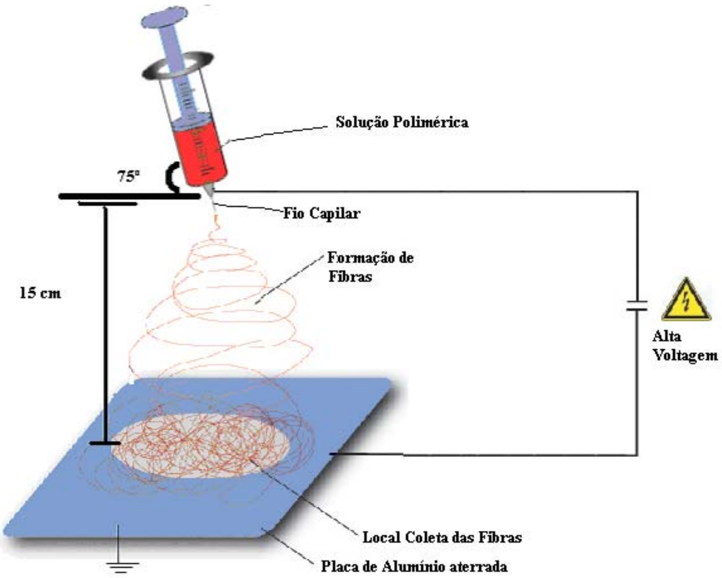

Figure 1: Electrospinning setup.

The fibers were electrospun using a homemade apparatus, Fig. 1, composed of a DC power supply (Gamma High Voltage Research Inc., 0 – 30 kV), a syringe (volume of 3 cm^3, needle type $26G^{5/8}$) and a collection screen (copper plate covered with aluminum, placed at a horizontal distance of 15 cm from the tip) that sustained the substrates. The samples were positioned in the center of the collection plate. We used a fixed potential difference of 15 kV between the tip and the grounded screen and a fixed deposition time of 1 min.

RESULTS AND DISCUSSION

In the figure 2 is observed that the electrospun nanofibers recovers completely the microfluidic cavities. Also, there is no nanofiber inside the cavities. In the figure 2 b) it is observed that nanofibers are almost aligned which is not observed in the circular feature.

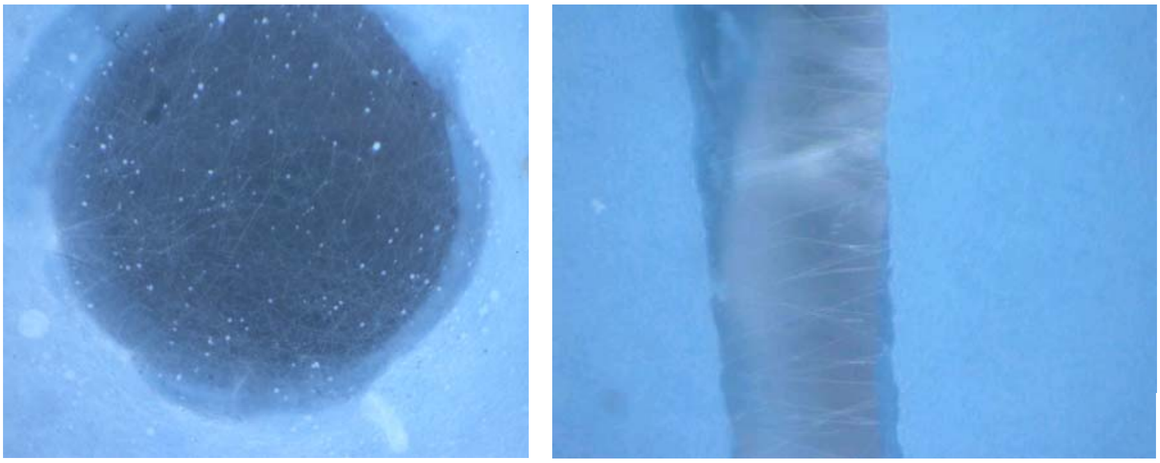

Figure 2: nanofibers electrospun over LTCC substrate a) hole (2 mm diameter), b)microchanne (1 mm)

One could explain the fiber alignment due to the presence of alumina and silicon oxide particles in the LTCC structure. It is well know that the LTCC is composed by a glass frit and alumina in a polymeric base. As that ceramic particle are isolated from each other, probably during the electrospinnig process some electrostatic charge are trapping in the particles promoting the attraction of the fibers. As a result is observed an aligned behavior in the electrospun nanofibers.

Figure 3: nanofiber deposited on corner

These results are confirmed by the image in the figure 3 where is shown a corner of LTCC with aligned fibers.

CONCLUSION

Electrospinning of nanofibers over LTCC substrate were performed. It was observed that the fibers have an aligned behavior when deposited over microchannel. This result may be attributed to the presence of alumina and silicon oxide on the LTCC structure.

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