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Optically Transparent Antennas and Filters

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Background

In this study, we developed optically transparent antennas and filters for the next generation smart cities. We envision that the cities of the future will have wireless capabilities that will utilize windows to receive and transmit information between buildings to create a smart network. In order to realize this vision, we consider transparent conductive oxides (TCOs), that are doped metal oxides with relatively high optical transparency and low electrical resistivity.

Currently, the most prevalent TCO is Indium Tin Oxide (ITO). However, Indium reserves in the world are diminishing, resulting in a rapid price increase. Therefore, it is critical that new and alternative materials are researched. Among such materials, Gallium Zinc Oxide (GZO) has features such as high conductivity and transparency that are attractive for the realization of optically transparent antennas and filters.

Design & Process

To demonstrate the feasibility of GZO antennas and filters, we consider a 2.4 GHz WiFi antenna, a 27.5 GHz 5G bandstop, and a 27.5 GHz 5G bandpass filter. After researching multiple topologies and performing simulations using the High Frequency electromagnetic Simulation Software (HFSS), we chose the configurations shown in **Figure 1**.

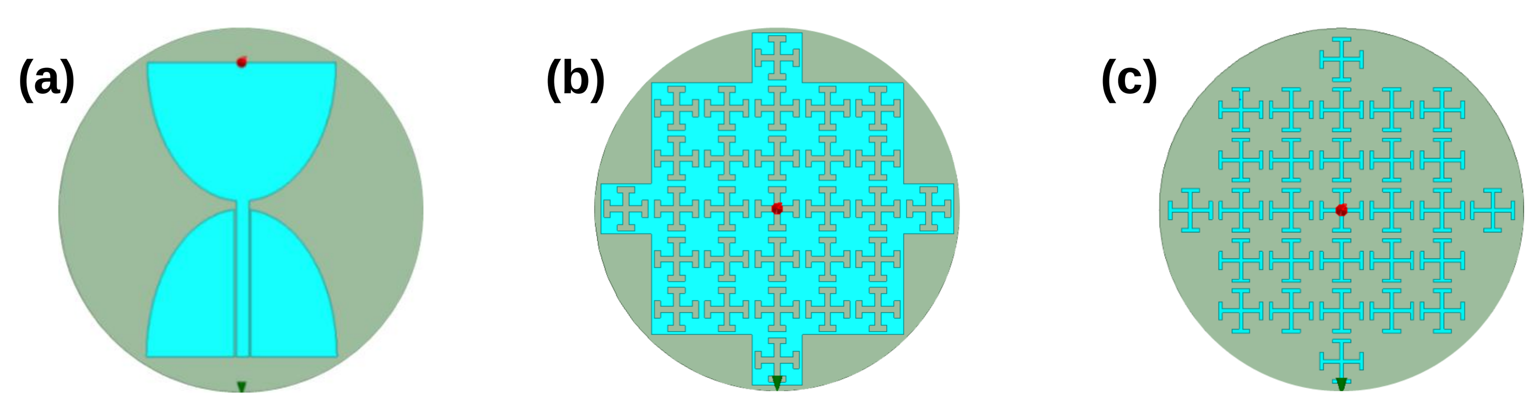

Figure 1: (a) Antenna, **(b)** Bandpass, and **(c)** Bandstop designs on HFSS

To realize the designs, we created three masks using µPG, as shown in **Figure 2**. Next, GZO was grown on a 2-inch sapphire wafer using molecular beam epitaxy (MBE) with an RF plasma oxygen source and the Knudsen cells used for Zinc and Gallium. The fabrication process included pattern generation, exposure, development, and etching, as shown in **Figure 2.**

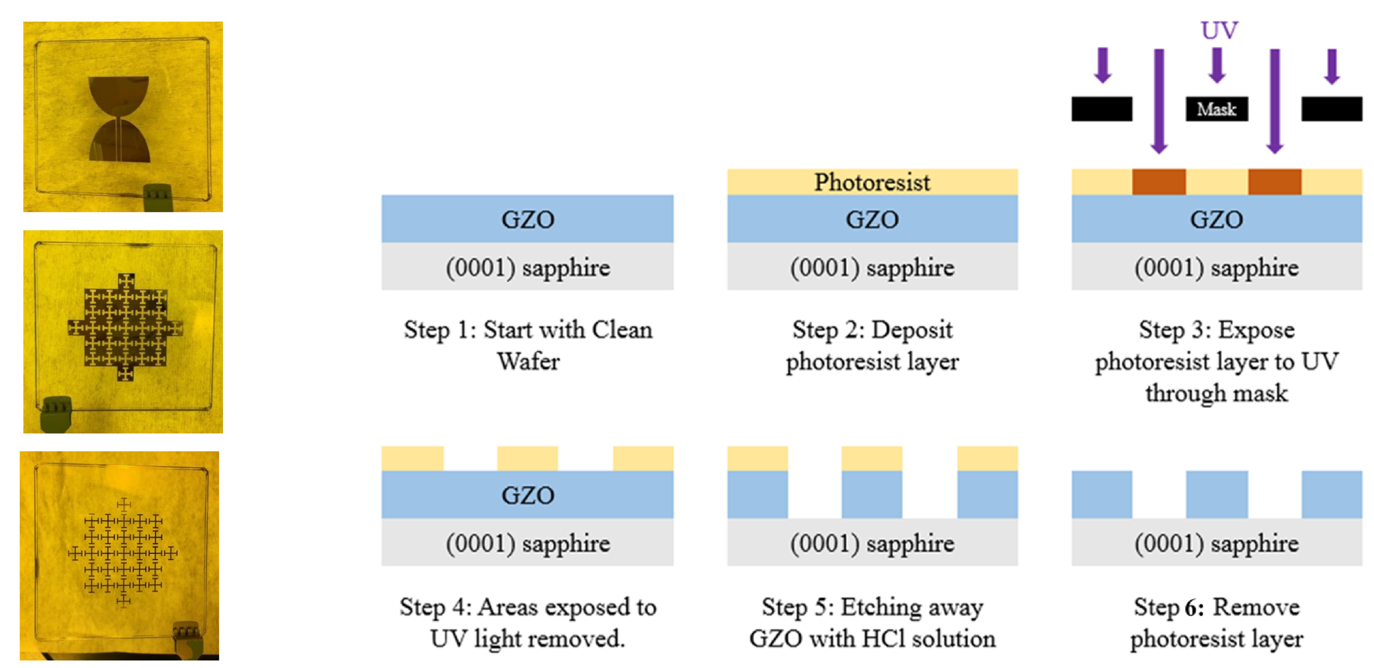

Figure 2: Fabrication Process

Results and Measurements

The measurement setup for both the antenna and the filters is shown in **Figure 3. Figure 4** shows the antenna return loss, bandpass and bandstop filter insertion losses, respectively. As seen from the figures, we achieved a reasonable performance using GZO as an alternative to conventional metal-based materials.

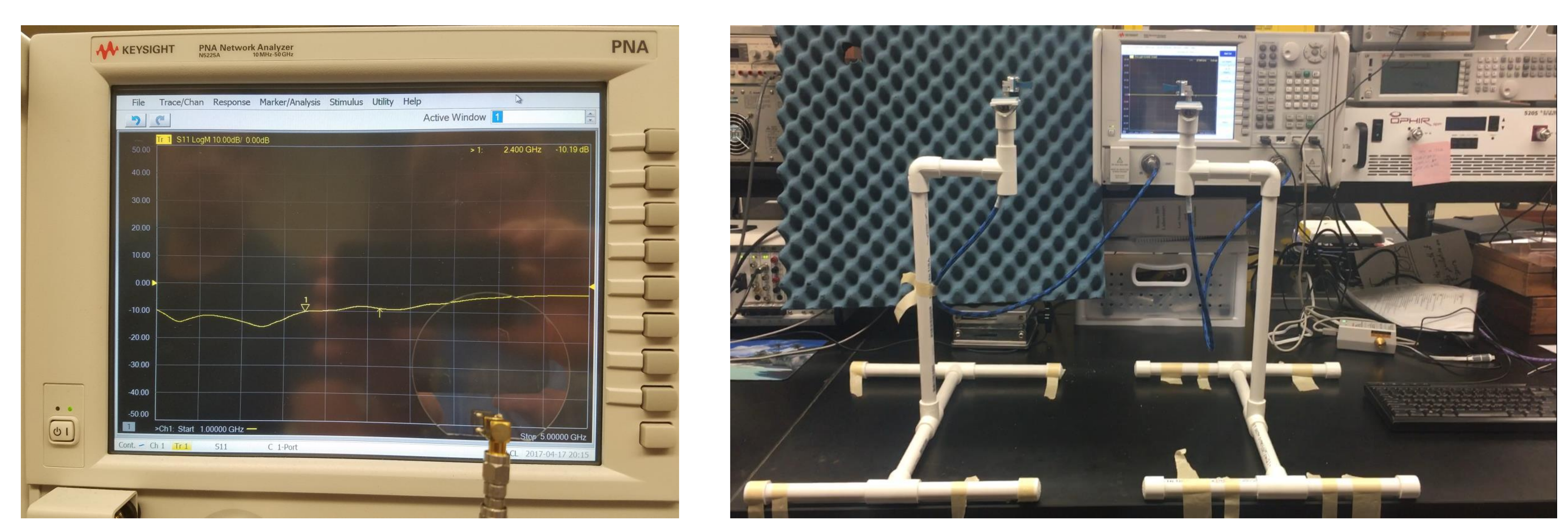

Figure 3: Antenna (left) and Filter (right) Testing Setups

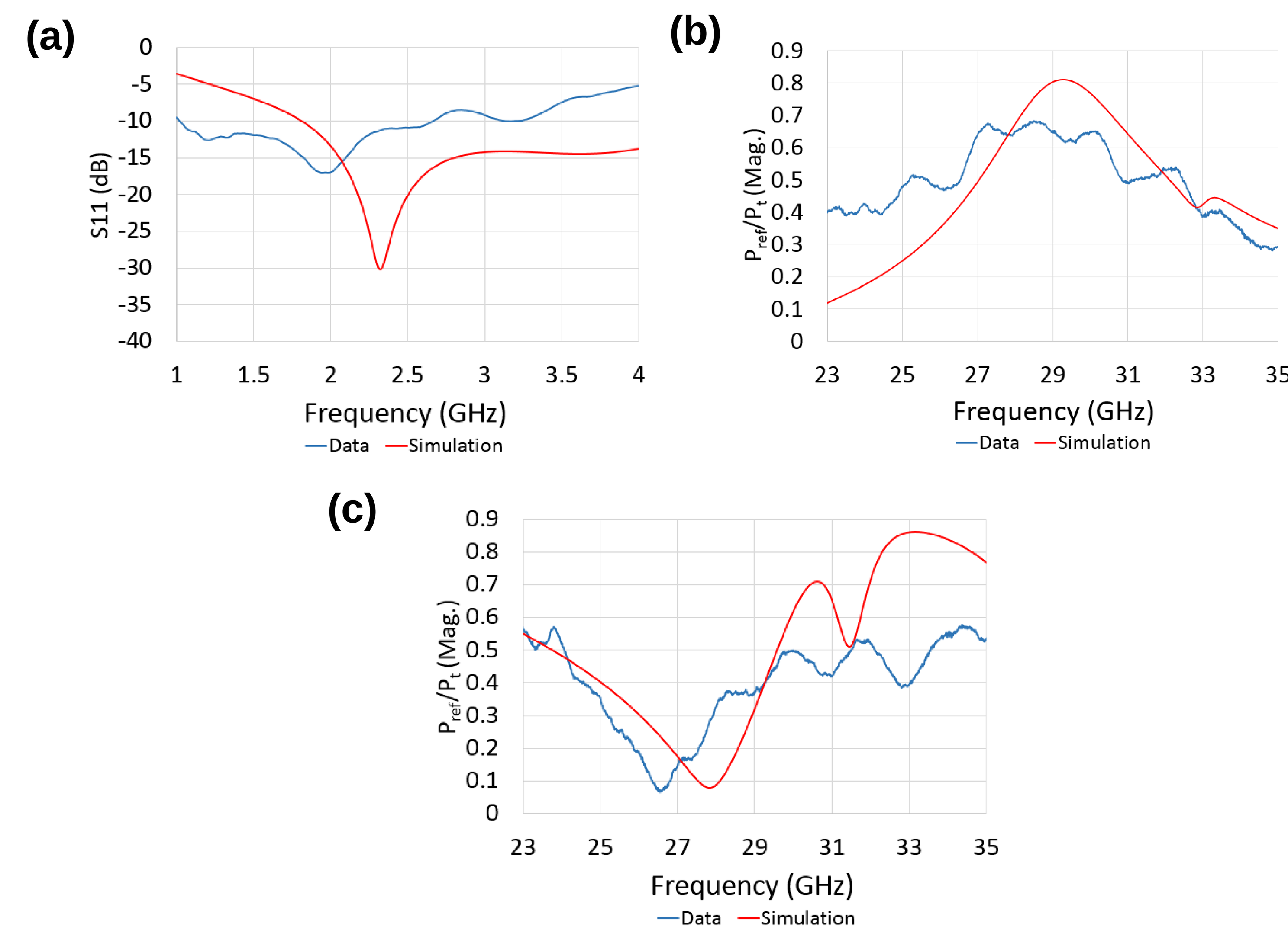

Figure 4: (a) Antenna Return Loss, **(b)** Bandpass Filter Insertion Loss, **(c)** Bandstop Filter Insertion Loss

Discussion

We designed, fabricated, and tested an optically transparent antenna and two filters. Our data shows that the antenna is operating at 2.4 GHz and the filters are blocking and passing frequencies at 27.5 GHz as designed.

Figure 5: GZO Antenna

Future Applications

Besides integrated optically transparent antennas and filters in windows, future potential applications include: night vision goggles, smart displays, and eyeglasses.

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