

Direct Sputter Deposition of Gold Thin-Film Sensors on Wood Substrates toward Chip-on-Wood Integration

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Summary: This work presents a first step toward realizing Chip-on-Wood systems, a novel integration concept in which microelectronic chips are directly mounted on wood substrates equipped with sputtered thin-film sensors. Gold thin-film structures were deposited on prepared beech wood surfaces via shadow mask sputtering, demonstrating good adhesion and continuous electrical conductivity. The approach eliminates conventional electrode insertion, reduces signal losses, and is fully compatible with future microelectronic integration, offering potential for miniaturized, energy-efficient sensing systems for structural health monitoring in timber construction.

Keywords: Thin-Film Sputtering, Wood Substrate, Structural Health Monitoring, Gold Metallization, Shadow Mask Patterning

Introduction

Wood is widely used as a sustainable building material in the construction industry. However, a key challenge is the high sensitivity of its mechanical properties to climatic fluctuations, which makes continuous structural health monitoring of wooden structures essential. Existing sensing approaches often require inserting electrodes into the wood, which can lead to interfacial failures or loss of signal accuracy [1][2]. Furthermore, due to their size such approaches cannot be integrated with microelectronics components.

To address these limitations, we propose a Chip-on-Wood integration concept, in which thin-film sensor structures are directly sputtered onto the wood surface, enabling future direct mounting of a microelectronic chip on the substrate. This eliminates contact losses at the electrode interface, improves signal integrity, and enables a fully integrated, miniaturized sensing system compatible with scalable deployment in the construction industry.

Fabrication Process

The fabrication process begins with the preparation of the wood substrate. To achieve a surface smooth enough for the sputtering process, the wood-substrates are ground using a metallographic polishing machine under controlled contact pressure and with various grit sizes (Tab. 1). Afterwards the samples were dried at 103 °C for 48 hours to achieve a wood moisture content close to 0 %.

Tab. 1: Grinding Parameters

grit size	contact pressure [N]	Rotation speed [1/min]	time [s]
320	5	130	180
600	5	130	180
1200	10	130	180

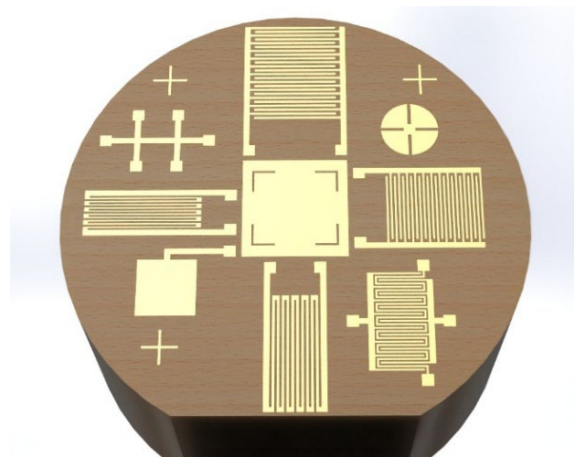


Fig. 1. Schematic representation of the sensor layout: Positioning of various sensor structures on the wood substrate.

The sensor layout is specifically optimized for the sanded wood substrate (Fig. 1). It includes various sensing structures (e.g. interdigital capacitor and strain gauge) in different structural sizes to qualify the aspect ratio of the shadow mask (200 µm). In addition, the layout includes structures for measuring the surface insulation

resistance, contact pads for bond testing, and reference points for orientation and layer thickness measurement.

For the sputtering process, a shadow mask with a thickness of 200 μm was pressed onto the wood substrate (Fig. 2). Through multiple sputtering processes a highly conductive gold layer was deposited.

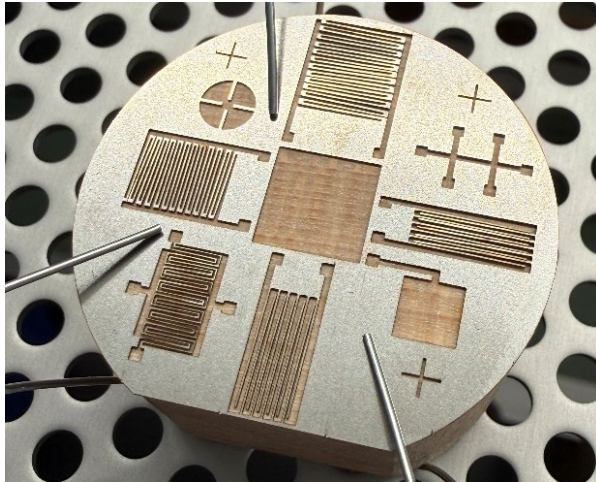


Fig. 2. Implementation of the sensor layout: A shadow mask (200 μm thick) fixed to the prepared wood sample to define the structures during the sputtering process.

Results

The results demonstrate that homogeneous gold layers can be directly deposited onto prepared wood surfaces by sputtering (Fig. 3). To verify the surface adhesion of the metallization to the substrate, a standard tape test was performed using 3M Crystal Tape. The results show a strong interfacial bond between the gold layer and the wood substrate.

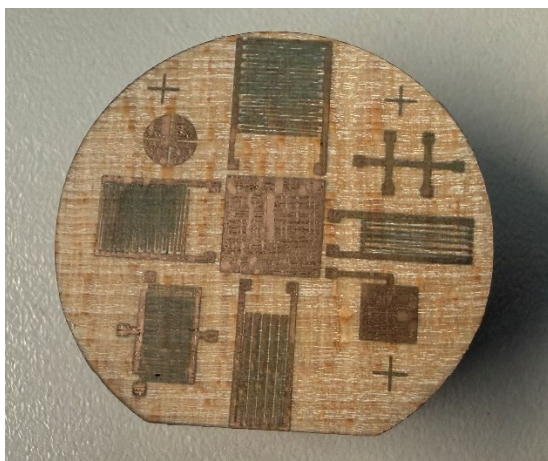


Fig. 3. Result of the sputtering process, a deposited and patterned gold thin film on a prepared beech wood surface.

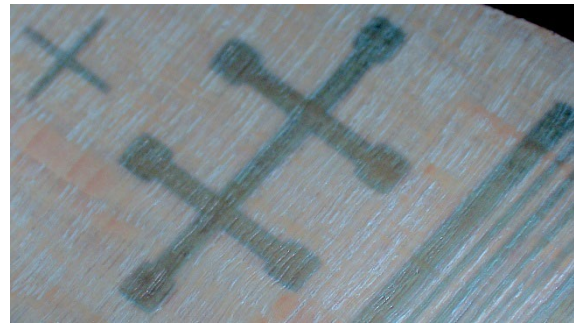


Fig. 4. Close-up of the macroscopic test structure used to determine the surface insulation resistance. Resistance values of 2 k Ω (long arm) and 1 k Ω (short arm) were successfully measured on this cross-shaped geometry.

The limited resolution of the shadow mask process currently prevents functional electrical characterization of microscopic IDC and strain gauge designs. Nevertheless, the overall metallization process has been validated. Using the macroscopic test structures, the surface insulation resistance of the sputtered gold thin film on the beech substrate was successfully quantified. The measured resistances were 2k Ω for the long arm and 1 k Ω for the short arm.

Conclusions

We present a new fabrication process for direct integration of sensor structures on wood substrates. The results confirm continuous electrical conductivity of the film and establish a key parameter for future high resolution sensor integration, opening up prospects for accurate and reliable sensing directly on wood substrates.

Future work will focus on optimizing the aspect ratio of the shadow mask to enable functional IDC and strain gauge structures. In addition, a capacitor-to-digital converter will be integrated directly on the wood substrate to realize a fully self-contained Chip-on-Wood sensing node for structural health monitoring.

References

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