# Fabrication methods for passive sensor tags on flexible polymer substrates

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Surface acoustic wave (SAW) devices enable wireless sensor nodes to operate in a locally passive mode in environments where battery and scavenged power is not viable. A number of groups have developed sensor tags that can monitor nearly any physical parameter[1-3], including tire health for automotive applications[4]. However, the majority of sensors that have been developed to date are based on rigid substrates and require connection to an external antenna. In this paper, we present a postage-stamp-sized low-profile SAW sensor tag with an integrated antenna on a flexible plastic substrate. These sensors can be peeled and applied like postage stamps to flat or curved surfaces.

Our SAW sensor tag is comprised of a thin-film antenna and commercial parts, including a SAW filter and a photodiode. A completed sensor tag is shown in Fig. 1. The antenna and metal traces are generated on polyethylene terephthalate (PET) and polyimide sheets using modified surface micromachining methods as shown in Fig. 2. The metal features are comprised of chrome, nickel, and gold layers with total thickness of 250 nm. A 25 µm thick passivation layer of SU-8 is deposited to define solder bumps for component attachment. Solder bumps are created by dipping the micromachined substrate in a liquefied bath of low temperature eutectic alloy. The commercial parts are positioned on the substrate, and the solder is reflowed. Upon cooling, the parts are mechanically and electrically connected to the sensor tag.

Simultaneous discernment between two tags at 0.2 m is demonstrated through frequency selectivity as shown in Fig. 3 (Left). Sensing at a distance of 3.6 m is shown in Fig. 3 (Right). Our fabrication methods enable wireless sensing with an inexpensive and highly versatile remotely-powered SAW-based flexible sensor tag.

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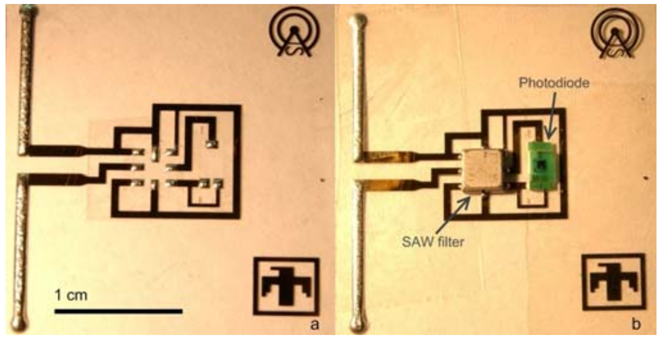


Figure 1: A low-profile flexible sensor tag based on SAW technology prior to (a) and after (b) commercial parts assembly.

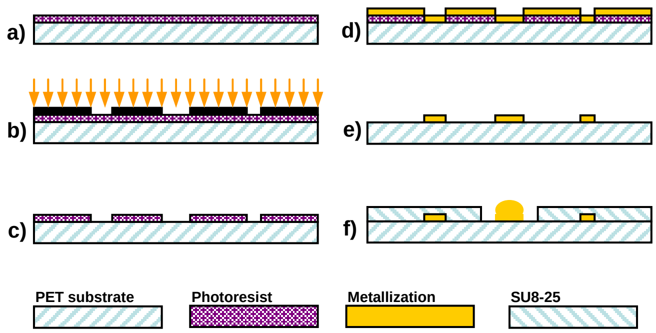


Figure 2: A layer of photoresist is deposited using PET compatible low-temperature processing (a). Patterns are generated using a mask and standard UV exposure (b). The features are developed (c), and metal is deposited using electron beam evaporation (d). Lift-off in acetone removes excess metal (e), and a SU8 passivation layer is patterned to define assembly sites and solder bumps (f).

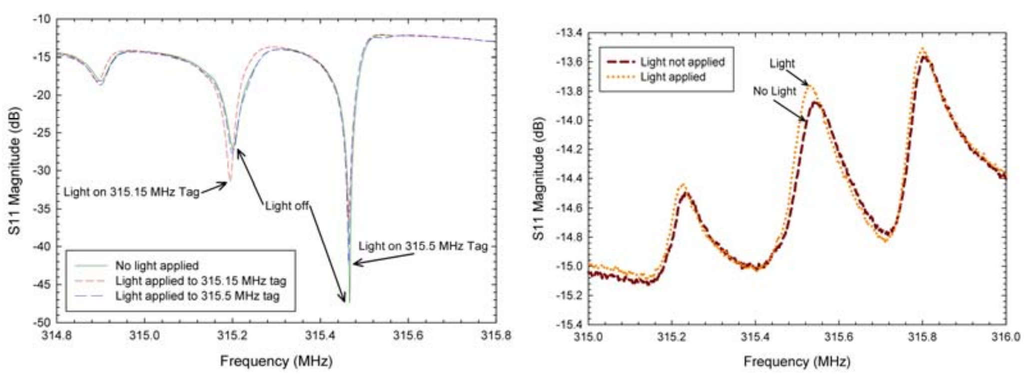


Figure 3: (Left) Received data at the network analyzer from a tag 0.2 m away. Data for light exclusively on tag 1, tag 2, and no light are shown. Each case can be disseminated by the magnitude shifts at the corresponding operating frequency of the tag. (Right) Light levels can be sensed at a distance of 3.6 m as indicated by changes in the magnitude response of $S_{11}$.