Anhydride-Assisted Room Temperature Sintering of Zn Nanoparticles and its applications in Printed Bioresorbable Electronics

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Abstract

Bioresorbable electronics technology that alters the built-to-last formats of conventional electronic devices draws great attention in recent years. With the gain of more fundamental knowledge in dissolution and failure mechanisms of the bioresorbable devices, humidity, temperature, pH values, and oxidation have been identified as major negative influencing factors that imposed stringent requirements to the fabrication and applications of such devices. Thus, bioresorbable devices have been achieved primarily by anhydrous Complementary Metal Oxide Semiconductor (CMOS) fabrication approaches. Ermerging printing electronic techniques utilize high-speed pulsed flashlight sintering[1], laser sintering[2], and acid-assist chemical sintering[3] to achieve conductive matrixes of bioresorbable nanoparticles. However, the optical sintering approaches that rely on energy absorption in the superficial layers limit the physical thickness of the printed patterns. On the other hand, acid-assisted chemical sintering that involves direct application of weak acid to the surface of the printed patterns may cause damage of the underneath substrates and difficulty in precisely controlling process parameters.

Here, we convert the negative effect of humidity into benefit, and utilize humidity to initiate single-step room-temperature sintering of an unique bioresorbable ink based on zinc nanoparticles (Zn NPs) and anhydride. The anhydride serves not only as the framework to enhance mechanical strength of the printed patterns, but also works as an initiator for the sintering process. The spontaneous oxidation on the surface of Zn NPs can be removed uniformly by the weak propionic acid generated by reaction between anhydride and water, resulting in formation of conductive paths through cold welding of particles. The entire process, which can be conducted at an environmental humidity of 90% in 300 mins is scalable to enable large scale bioresorbable devices. The resulting devices achieved an electrical conductivity of more than 72400 S/m with high mechanical robustness. A radio circuit have been demonstrated to operate stably over 14 days in atmosphere environments and disappear in water less than 1 hours. The rapid and energy-efficient fabrication of bioresorbable devices demonstrates a new concept that utilizes dual characters of the influencing factors in achieving bioresorbable electronics. More printable devices with high mechanical robustness and electrical performance can be readily achieved to generate boarder impacts in the areas of health care, information security, and consumer electronics.

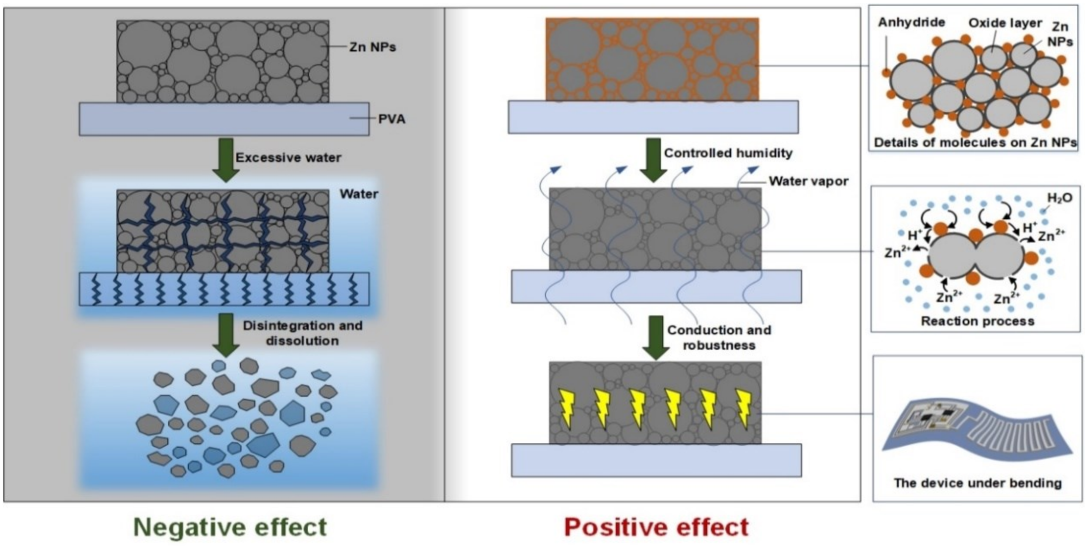

Figure 1: Micro schematic of Anhydride-Assisted sintering under the wet environment.

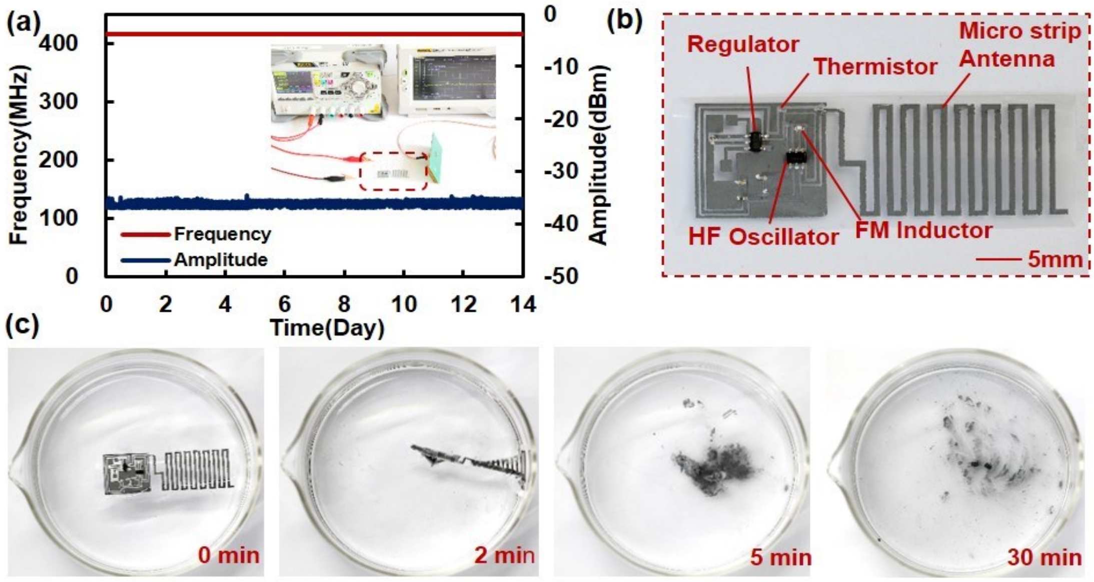

Figure 2: (a)The result of the test lasted for 14 days without external interference (b) the image of the high frequency oscillator and antenna by screen printing (c) Images showing the degradation process of a high frequency oscillator circuit in DI water at room temperature.

References

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