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Metal-Polymer Series Connection Hybrid Stent integrated with PI based Wireless Pressure Sensor

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Abstract

This paper introduces a novel hybrid stent design with a wireless pressure sensor based on polyimide (PI), which offers efficient and stable pressure sensing during stent deployment. The proposed design overcomes the limitations of traditional smart stents and presents a promising solution for practical applications. The key difference between this new design and previous work lies in the metal-polymer series connection hybrid stent, which was achieved using a home-made 3D printing system. The fabricated smart stent provides improved mechanical support and flexibility, thereby facilitating smooth insertion into blood vessels. Furthermore, the wireless pressure sensor based on PI enhances the stability of the sensor's performance compared to conventional SU-8 sensors.

Background

Stent, a small tube that opens narrowed arteries, improve blood flow to the heart and reducing heart attack risk. Since the first bare-metal stent was introduced in the 1980s, stents have undergone significant advancements. Metal stent and polymer stent is the most common stent which is under research. But these traditional stents have their respective drawbacks. Metal stents can decrease the sensitivity of pressure sensors due to their electrical and mechanical properties, while biodegradable stents have weak mechanical properties that hinder their insertion into blood vessels. In addition, wireless pressure sensor is combined with stent to provide continuous blood pressure monitoring. SU-8 pressure sensor is not stable and flexibility due to the SU-8 material. [1]

Experimental

Figure 1 presents a schematic view of the novel design and highlights its advantages compared to conventional metal or polymer stents. The hybrid stent design consists of two distinct components arranged in series: a metal segment followed by a polymer segment, with another metal segment completing the series connection. The metal segments are derived from commercial metal stents and are laser-cut to the required length, while the polymer segment is fabricated using a 3D printing machine.

Result and Discussion

Figure 3 illustrates the metal-polymer series connection hybrid stent design, utilizing PLA and PCL materials. Figure 4 displays the radial force of five different stent types. The results indicate the hybrid stent fabricated using PLA material exhibits comparable radial force to that of the metal stent, thus attesting to the robust mechanical characteristics of the hybrid stent. Figure 5 shows wireless pressure sensor combine with different stent and signal change when combed with different stent. It is evident that the utilization of hybrid stents does not exhibit a reduction in signal strength of the sensor, while the implementation of metal stents results in a decrease in the sensor's signal strength. Figure 6 illustrates the frequency change of the wireless pressure sensor under different air pressures when combined with different stent types. The frequency change of sensor combined with hybrid stent have no significant difference compared to sensor combined with PCL stent. Figure 7 presents wireless pressure sensor performance in the Phantom system. The sensor shows that the rapid and accurate frequency change to water pressure changes which indicate the stable performance of the wireless pressure sensor.

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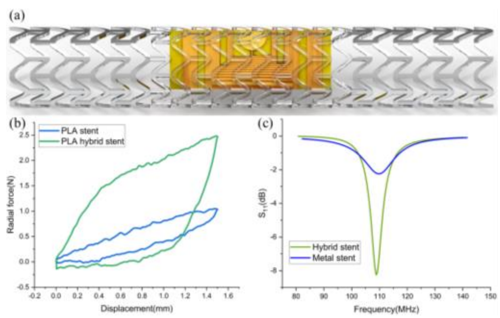

Fig 1. Schematic of new design. (a)device Schematic;(b) Radial force of PLA stent and hybrid stent;(c) S11 amplitude of hybrid stent and metal stent.

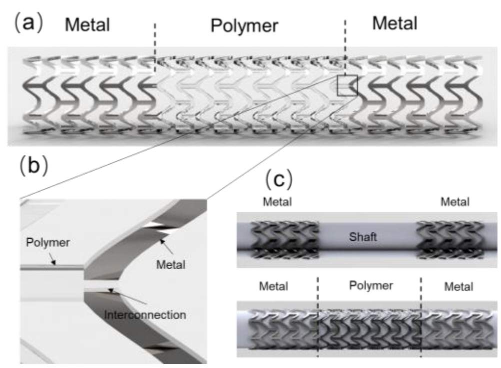

Fig 2. Metal-Polymer sandwich structure hybrid stent design. (a)Schematic of metal-polymer sandwich structure hybrid stent;(b) Connection structure between metal stent and polymer stent;(c)fabrication flow of hybrid stent.

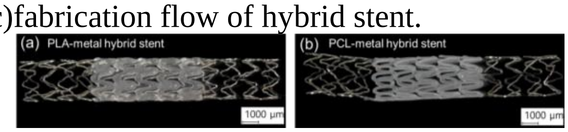

Fig 3. Different types of Hybrid Stent. (a)PLA-Metal sandwich structure hybrid stent;(b) PCL-Metal sandwich structure hybrid Stent.

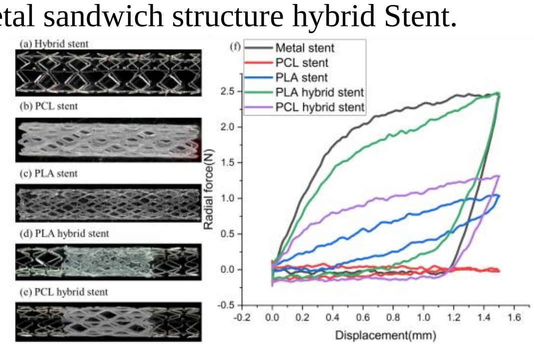

Fig 4. Radial force of five different kind stent. (a) Hybrid stent; (b) PCL stent; (c) PLA stent; (d) PLA hybrid stent; (e) PCL hybrid stent; (e) Radial force of five different kind stent.

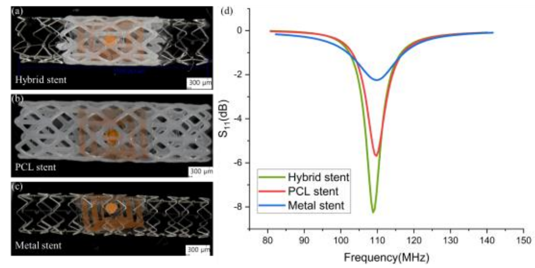

Fig 5. Sensor S_{11} amplitude change when combined with different kinds of stent. (a)Hybrid stent;(b) PCL stent;(c) metal stent;(d) S_{11} amplitude change

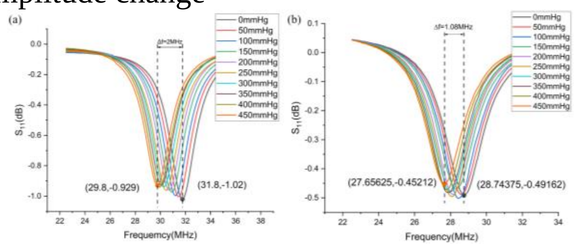

Fig 6. Wireless pressure sensor frequency change under different air pressure combined with different stent.

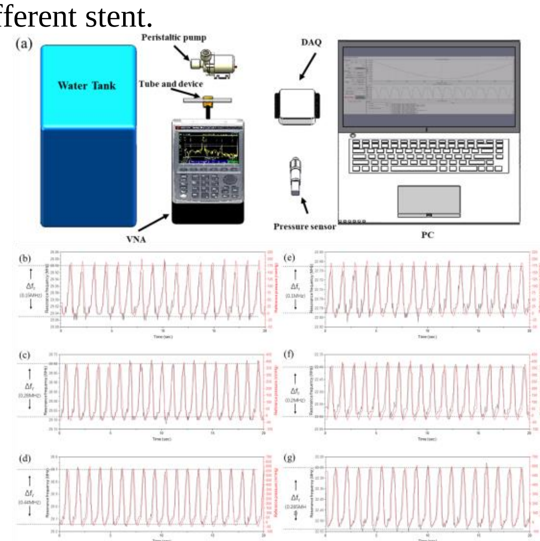

Fig 7. Wireless pressure sensor frequency change under different water pressure in the Phantom system combined with different stent. (a) Phantom system; (b-d) 200/400/600mmHg in PCL stent; (e-g) 200/400/600mmHg in hybrid stent.

REFERENCES

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