HeartBeat - Inkjet printed platform on polymer foil for the functional monitoring of cardiomyocyte cells

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1. Motivation

The functionality of human stem cell-derived cardiomyocytes, to assess the cardiotoxicity of drug candidates, is of great interest for medical research. This requires a cost-effective test system with fast optical and electrical contraction measurement for autonomously contracting cardiomyocyte clusters.

2. Approach

The HeartBeat project combines the expertise of inkjet printing of nano-inks on polymer foils with biomaterials, cell-based in-vitro test systems and their sensors. The project demonstrates an optical and electrical test platform for the vitality monitoring of cardiomyocyte cell models.

3. Results

Conductive gold, platinum and graphene inks were successfully tested regarding their printed film biocompatibility (DIN ISO 10993) and their influence on contracting cardiomyocytes. Flexible polymer foils were evaluated for ink printing, thermal stability for ink sintering and their ability to be used in optical sensors (transmission properties by absorption spectrometer). Polyimide (PI), polyurethane (PU) and polyethylenterephthalat (PET) foils were evaluated for their suitability as cell culture surface for induced pluripotent stem cells (iPSC)-derived cardiomyocytes. Appropriate proteins were selected to optimize the adhesion and maturation of the cardiomyocytes on these foils. Interdigital electrodes were inkjet-printed with commercial and with Fraunhofer IKTS inks. A thin PET foil and an IKTS gold ink were selected for scaling, since these materials achieved good results in preliminary tests regarding biocompatibility, heart cell growth, sintering parameters and optical foil properties. The printed gold electrodes were successfully sintered at rather low temperatures of 150 °C to achieve resistivity values of < 60 µOhm*cm or even < 20 µOhm*cm by fast line laser treatment. An electrode layout was developed to measure electrical signals of cardiomyocytes, optimized for inkjet printing and scaled to A4 size printing. Four-point measurement conductor tracks allowed the connection with commercial ZIF connectors. The flexible electrodes were assembled with commercial cell culture vessels and the cardiomyocytes were successfully cultivated (Fig.1). A modified “contraction reader” setup demonstrated the combined optical and electrical measurement of cell potentials. The electrophysiological measurements provided an insight into the stimulation of the cardiomyocytes, while the optical measurement recorded the contraction frequency (Fig.2).

Conclusion

An inkjet-printed electrode platform on polymer foil demonstrated the optical and electrophysiological monitoring of autonomously contracting cardiac cells. This enables a multifactorial monitoring of stem cell-derived cardiomyocytes and can provide new insights for drug development, toxicological screenings, and biosensor product developments.

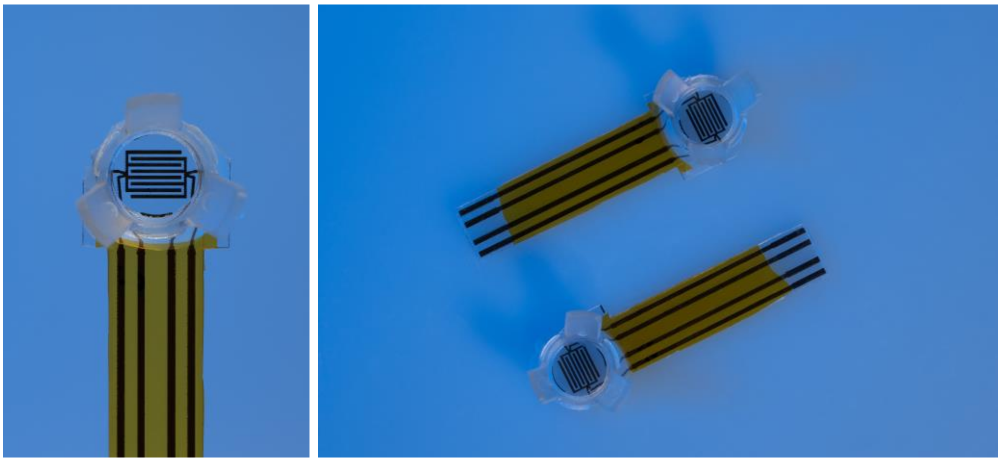

Fig.2: Cell platform with integrated printed gold electrodes.

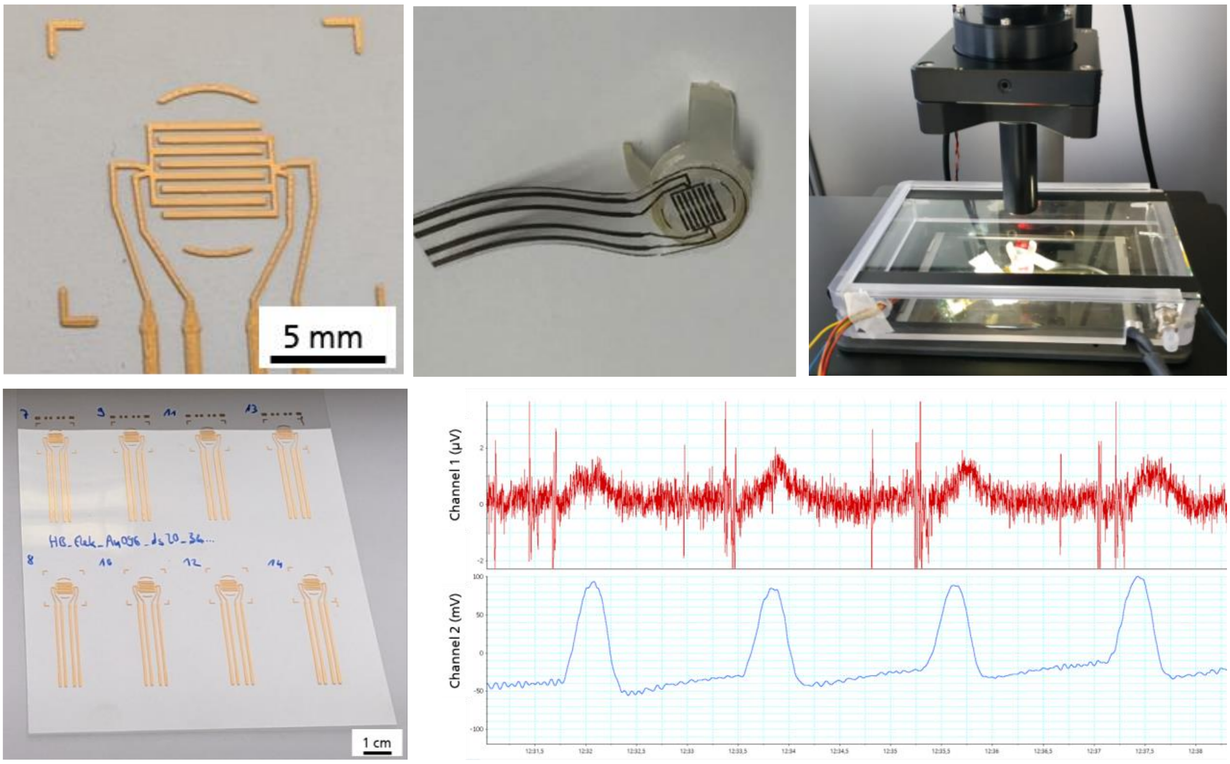

Fig.1: Printed gold electrodes on PET foil and cardiomyocyte measurements set-up.