High Resolution, Low Resistance Printed Electrical Conductors Utilizing Roll-to-Roll Imprinted Plastic Substrates

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Extended Abstract:

High performance conductors are an essential building block for electrical circuits since they function as interconnects between individual circuit components. Ideal interconnects demonstrate low electrical resistance while requiring minimal device surface area. This promotes high device density in fabricated circuits. Additive manufacturing techniques like printing are beneficial for fabricating electronic components due to their low cost and limited waste. Consequently, the ability to form high aspect ratio, printed metal conductors (feature height / feature width) with precise positioning is very important to the field of printed electronics. Although traditional printing techniques are compatible with roll-to-roll production, they face a series of limitations for fabricating metal conductors. Normal printing techniques struggle to form high aspect ratio features due to the spreading of ink after printing. Traditional printing techniques also struggle to form the high resolution, contiguous features needed for electrical conductors due to ink delivery limitations. Ink spreading and alignment difficulties make it very challenging to position printed features with the micrometer precision needed for high-density circuits. However, UV micro-molding can form significantly higher resolution and higher aspect ratio features on plastic substrates while still compatible with roll-to-roll processing. Thus, we have combined high resolution roll-to-roll UV micromolding with roll-to-roll compatible inkjet printing to address these issues. By utilizing roll-to-roll UV micromolding on plastic substrates, we can form capillary channels with aspect ratios greater than 1 and with sub-micrometer positional accuracy. Roll-to-roll compatible inkjet printing then deposits metallic inks into reservoirs connected to the channels and spontaneous capillary flow fills the channels with ink. After drying, copper electroless plating is used to fill the channels with metal to form precisely positioned, high aspect ratio metal conductors. Channels 30 μm wide are utilized in this process to form conductors with linear resistances as low as 0.4 Ω/cm. Networks of these conductor channels can be combined to form multi-point interconnects which demonstrate the ability to connect nine circuit locations while only requiring ink deposition into a single location. This process demonstrates a highly beneficial building block for the fabrication of advanced printed electronic devices and circuits.

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