Electrowetting Beam Steering Device: Towards Energy Efficient Mm-Wave Wireless Network

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***Abstract*— Millimeter Wave communication is a major technology for sixth generations (6G) of wireless systems, it suffers from severe signal blockage, attenuation, and use of massive number of antennas and large bandwidth leads to consume enormous energy consumptions. These significantly limit the link reliability and communication performance of such systems. To tackle these challenges, we introduced a novel, efficient and innovative Reconfigurable Intelligent Surface (RIS) based on Electrowetting beamforming devices for mm-Wave communications.**

Keywords— Electrowetting, mm-Wave, RIS, 6G, Beam-steering

I. INTRODUCTION

Wireless communications had a major impact on a diverse range of areas such as economy, education, health, entertainment, logistics, and travel. In order to satisfy the ever-growing demand for higher data-rates and bandwidth, the sixth generation (6G) wireless networks envision communication in a spectrum which includes frequencies above 28 GHz and especially the millimeter wave (mm-Wave) bands. The application of high carrier frequencies in mm-wave systems allows for larger channel bandwidths compared to the current RF (radio frequency) systems which operate in lower frequency bands. However, the energy consumption of constituent circuit and system components such as analog to digital converters and digital to analog converters increases significantly with bandwidth. The massive number of transceiver antennas and large bandwidth lead to substantial energy consumption in mm-wave multiple-input multiple-output (MIMO) systems which is inconsistent with the limited energy budget in mobile devices and small-cell access points [1][2]. Therefore, it is an urgent need for the design of reconfigurable intelligent surface (RIS) which consumes less power to complete a programmable environment to solve the problems derived from high directivity of mm-wave. With this mind, we sought an attempt for the design and fabrication of electrowetting (As the shape of the liquid can be changed by the applied potential in real time) based beam steering device, those technology are highly applicable for mm-wave communications for the first time.

II. DEVICE DESIGN AND EVALUATION

Electrowetting device (EWD) consisting of two plates, filled with water and colored oil. Both the cover plate and the substrate have conductive layers functioning as the top and bottom electrodes. For the bottom plate, pixel structures are built on a hydrophobic insulating coating of the bottom electrode. The colored oil forms a thin film in an individual pixel between the water and the hydrophobic layer [3][4]. EWD with an applied voltage, homogeneous oil film spreads over the pixel area showing the color of the dyed oil.

For the first time, we have implemented the EWD through a real-time beamforming testbed in 28 GHz. Interestingly, the developed RIS can dynamically control the beam tuning property based on EWD cell structure changes the contact angle with respect to an applied voltage, as illustrated in Fig.1. In conclusion, this study opens up a new window for the design of novel RIS devices and also will be implemented in a practical industrial application in order to reduce the hardware cost, complexity and mainly for power consumption by decreased the number of antennas.

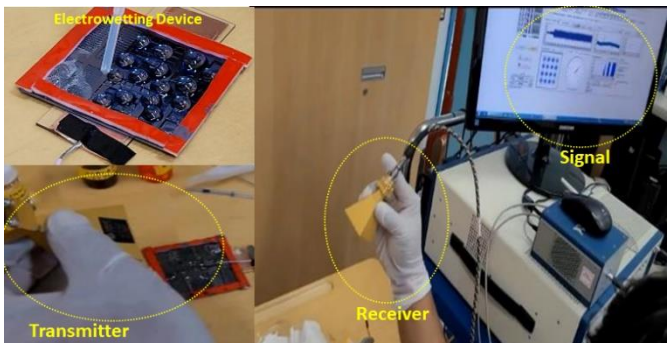

Fig. 1. Electrowetting device and mm-wave testbed experimental results

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