Research and Development

Extended Abstract

Graphene 2018: Stretchable and hydrophobic electrochromic devices using wrinkled graphene and PEDOT PSS-Hossein Sojoudi-University of Toledo, Ohio

Abstract

We present an electrochromic device (ECD) fabricated using PEDOT:PSS and graphene as active conductive electrode films and a flexible compliant polyurethane substrate with 1-ethyl-3-methylimidazolium bis(trifluoromethyl sulfonyl) imide (EMI-TSFI) additive, as ionic medium. This device with a docile, elastic intermediate substrate along with a transparency controlled PEDOT:PSS film provides a wide color contrast and fast switching rate. We harness wrinkling instability of graphene to achieve a hydrophobic nature without compromising transparency of the ECD. This mechanical self-assembly approach helps in controlling the wavelength of wrinkles generated by inducing measured pretrain conditions and regulating the modulus contrast by selection of underlying materials used, hereby controlling the extent of transparency. The reduction and oxidation switching times for the device were analyzed to be 5.76 s and 5.34 s for a 90% transmittance change at an operating DC voltage of 15 ± 0.1 V. Strain dependent studies show that the performance was robust with the device retaining switching contrasts even at 15% uniaxial strain conditions. Our device also exhibits superior antiwetting properties with an average water contact angle of 110° ± 2° at an induced radial pretrain of 30% in the graphene film. A wide range color contrast, flexibility, and antiwetting nature of the device envision its uses in smart windows, visors, and other wearable equipment where these functionalities are of outmost importance for developing new generation of smart interactive devices.

Electromagnetic Devices have achieved widespread attention over the past decade due to their strong design, ease of manufacturing, and power saving low power operation mechanisms. usual materials like transition metals like actinides and lanthanides have been generally exploited for exhibiting electrochromic properties in devices. At present, indium tin oxide(ITO) Is a broadly used transparent conductive electrode in electronics and organic photovoltaics (OPVs), The price of manufacturing of indium as a uncommon earth metal rises always with depleting resources. Moreover, deposition of ITO on flexible substrates is difficult as it increases its defect densities due to ambient temperature deposition methods and radically reduces its carrier concentration . While the concept of electrochromic switching has been stated as early as the

Seventies , presently lookup is greater targeted on creating organic polymers which show off similar performance and properties when compared to their metal counterparts while being extra viable, sustainable, and environmentally friendly. PEDOT:PSS (poly(3,4-ethylenedioxythiophene)
polystyrene sulfonate) is an natural polymer from the family of thiophenes that has shown very promising consequences owing to its greater conductivity, greater environmental and electrochemical stability, and its conformity as a water-processable polymer main to giant lookup in the discipline of flexible electronics and as an choice to traditional metal oxide based totally electrochromic systems. Electrochromic contrast is an essential parameter in the overall performance evaluation of such systems. PEDOT:PSS gives excessive optical contrasts between its redox states enabling this monochromatic transition between colored and bleached states beneficial in developing absorption and transmission type devices like smart windows and visors.

Moreover, graphene has superior mechanical, optical, and electrical residences enabling its use in transparent electronic and photonic devices. These properties of graphene have made it an great candidate as a transparent conductive electrode. Graphene synthesized through chemical vapor deposition (CVD) on transition metals results in formation of giant scale films with minimized structural defects, enabling its purposes on an industrial scale . In addition, studies have shown that controlled surface geometry of graphene can alter the wetting properties of the film, giving upward push to superhydrophobic surfaces. Here, the mechanical instability of graphene is harnessed to develop wrinkles on the film by applying radial stress to soft underlying substrate. While PEDOT:PSS and graphene have been used as conductive electrodes in electronics and photonics, the built-in electrochromic and hydrophobic properties of these materials have not been studied. It is revealed a working electrochromic machine which is flexible and stretchable, whilst exhibiting superior antiwetting properties. Graphene-based flexible electrochromic devices have been visualized in the past . However, principal challenges lie in developing a sturdy gadget shape which is free of liquid electrolytes that are hazardous to health and environment. Leakage of cell components is highly undesirable in optoelectronics, specifically in wearable devices. Here, we incorporate the electrolyte in a stretchable elastomer base which ensures an ionic conductivity and permits flexibility of the device, whilst bettering safety.

Wrinkling or buckling in thin films is brought on due to prompted stresses in the components. The instability arises due to the compression of an interface leading to a deformation which propagates modifications in surface properties. This out-of-plane deformation of graphene enhances the adhesion energy of the stiff films to compliant substrates. It is located that the morphology of the generated wrinkles is generally established on the floor texture of the underlying substrate, with larger floor roughness contributing to higher wrinkling. This reversible instability can be harnessed to generate various characteristics in surface morphologies that are of splendid importance in nanofabrication of elastic optoelectronic devices. To this end, we appoint a compliant elastomer (polyurethane) containing ionic liquid as dielectric medium and comprise PEDOT:PSS/Xylitol films as the electrode, which reveals electrochromic nature upon applying voltages, and graphene, which acts as the hydrophobic counter electrode. Our system shows more advantageous bleaching

price and steady functionality at variable strain rates envisioning its potential in bendy electronics. This novel of stable, transparent, and routinely flexible videos gives a new viewpoint for optoelectronic devices.
CVD graphene on copper used to be purchased from ACS fabric and ferric chloride-based copper etchant was purchased from Sigma-Aldrich. Graphene was stamped to a 2 mm thick PDMS substrate and etched in the etching answer for 30 minutes. The graphene on PDMS was cleaned with deionized water carefully and blow-dried with air/nitrogen before switch to the PU/IL substrate by using stamping. The surface morphology of graphene can be in further tuned to show off greater water contact angle values while exhibiting most desirable conductivity. This combined with a purpose of an organic polymer like PEDOT:PSS as a flexible transparent conductive electrode can result in growing ECDs with stronger functionalities, enabling their application in areas where there is continual exposure to water stretching/flexing conditions.

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