ACS NANO
Cite This: ACS Nano 2019, 13, 13161−13168
www.acsnano.org
ARTICLE

Piezotronic Effect Modulated Flexible AlGaN/GaN High-Electron-Mobility Transistors

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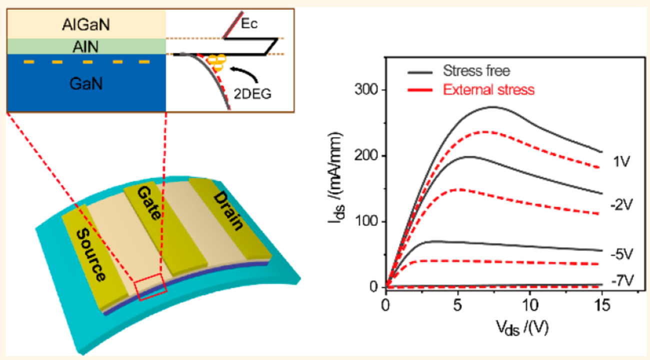
Supporting Information



ABSTRACT: **Flexible electronic technology has attracted great attention due to its wide range of potential applications in the fields of healthcare, robotics, and artificial intelligence, *etc*. In this work, we have successfully fabricated flexible AlGaN/GaN high-electron-mobility transistors (HEMTs) arrays through a low-damage and wafer-scale substrate transfer technology from a rigid Si substrate. The flexible AlGaN/GaN HEMTs have excellent electrical performances with the $I_{d,max}$ achieving 290 mA/mm at V_{gs} = +2 V and the $g_{m,max}$ reaching to 40 mS/mm. The piezotronic effect provides a different freedom to optimize device performances, and flexible HEMTs can endure the larger mechanical distortions. Based on the piezotronic effect, we applied an external stress to significantly modulate the electrical performances of flexible HEMTs. The piezotronic effect modulated flexible AlGaN/GaN HEMTs exhibit great potential in human-machine interface, intelligent microinductor systems, and active sensors, *etc*, and introduce an opportunity to sensing or feedback external mechanical stimuli and so on.**

KEYWORDS: *AlGaN/GaN high-electron-mobility transistors, flexible substrate, piezotronic effect, two-dimensional electron gas, wafer-scale*

In recent years, flexible electronic technology has shown a rapid development trend,[1] opening a wide range of potential applications for energy harvesting, medical healthcare, consumer electronics, robotics, *etc.*[2] Thanks to the high saturation drift velocity, high sheet carrier concentration, wide band gap, and excellent frequency characteristics,[3] AlGaN/GaN high-electron-mobility transistors (HEMTs) are the best candidates for radio frequency (RF), microwave devices and power devices and so on.[4] The flexible HEMTs are expected to satisfy the urgent requirements of the wireless communication and electrical supply in flexible electronics. However, due to the limitation of growth kinetics, AlGaN/GaN HEMTs are usually fabricated on rigid substrates such as Si, sapphire, or SiC, thus they cannot be applied to nonplanar environments and are hard to deform. The substrate transfer technology has received a lot of attention and rapid developments, and some flexible AlGaN/GaN HEMTs have been fabricated with various substrate transfer technologies, for example, a mechanical lapping and etching,[5] a sacrificial 2D boron nitride layer,[6] and a xenon difluoride etching.[7] Alleviating the devices performances degradation on flexible substrates is still a significant issue. In addition, flexible substrates provide some different functions such as flexible structures, stretchable structures, and curved conformal installations, which induce complex stress distribution to greatly affect the electrical characteristics.[8]

The piezotronic effect proposed by Z. L. Wang utilizes piezoelectric polarization charge to change the energy band structure at the interface or junction to control carrier transport.[9−12] III-nitrides are ideal piezotronic materials and have wide industrial applications. The AlGaN and GaN have strong spontaneous polarization and piezoelectric polarization, resulting in a strong polarization electric field in the AlGaN/

Received: July 30, 2019
Accepted: October 21, 2019
Published: October 21, 2019

DOI: 10.1021/acsnano.9b05999
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