Supplementary Information:

Synthesis and Characteristics of Transferrable Single-Crystalline AlN Nano-membranes

Jiarui Gong[1,2,†], Jie Zhou[2,†], Ping Wang[3,†], Tae-Hyeon Kim[4], Kuangye Lu[5], Seunghwan Min[2], Ranveer Singh[2], Moheb Sheikhi[2], Haris Naeem Abbasi[2], Daniel Vincent[2], Ding Wang[3], Neil Campbell[1], Timothy Grotjohn[6], Mark Rzchowski[1], Jeehwan Kim[5], Edward T. Yu[4,], Zetian Mi[3,*], and Zhenqiang Ma[2,*]*

Jiarui Gong, Neil Campbell, Mark Rzchowski
[1]Department of Physics, University of Wisconsin-Madison, Madison, Wisconsin, 53706, USA

Jiarui Gong, Jie Zhou, Seunghwan Min, Ranveer Singh, Moheb Sheikhi, Haris Naeem Abbasi, Daniel Vincent, Zhenqiang Ma
[2]Department of Electrical and Computer Engineering, University of Wisconsin-Madison, Madison, Wisconsin, 53706, USA
Email: mazq@engr.wisc.edu

Ping Wang, Ding Wang, Zetian Mi
[3]Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, Michigan, 48109, USA
Email: ztmi@umich.edu

Tae-Hyeon Kim, Edward T. Yu
[4]Microelectronics Research Center, Department of Electrical Engineering and Computer Science, University of Texas at Austin, Austin, Texas, 78758, USA
Email: ety@ece.utexas.edu

Kuangye Lu, Jeehwan Kim
[5]Department of Mechanical Engineering, Department of Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, 02139, USA

Timothy Grotjohn
[6]Department of Electrical and Computer Engineering, Michigan State University, East Lansing, Michigan, 48824, USA

[†]These authors contributed equally to this work.
[*]Author to whom correspondence should be addressed. Electronic mail: mazq@engr.wisc.edu, ztmi@umich.edu, ety@ece.utexas.edu

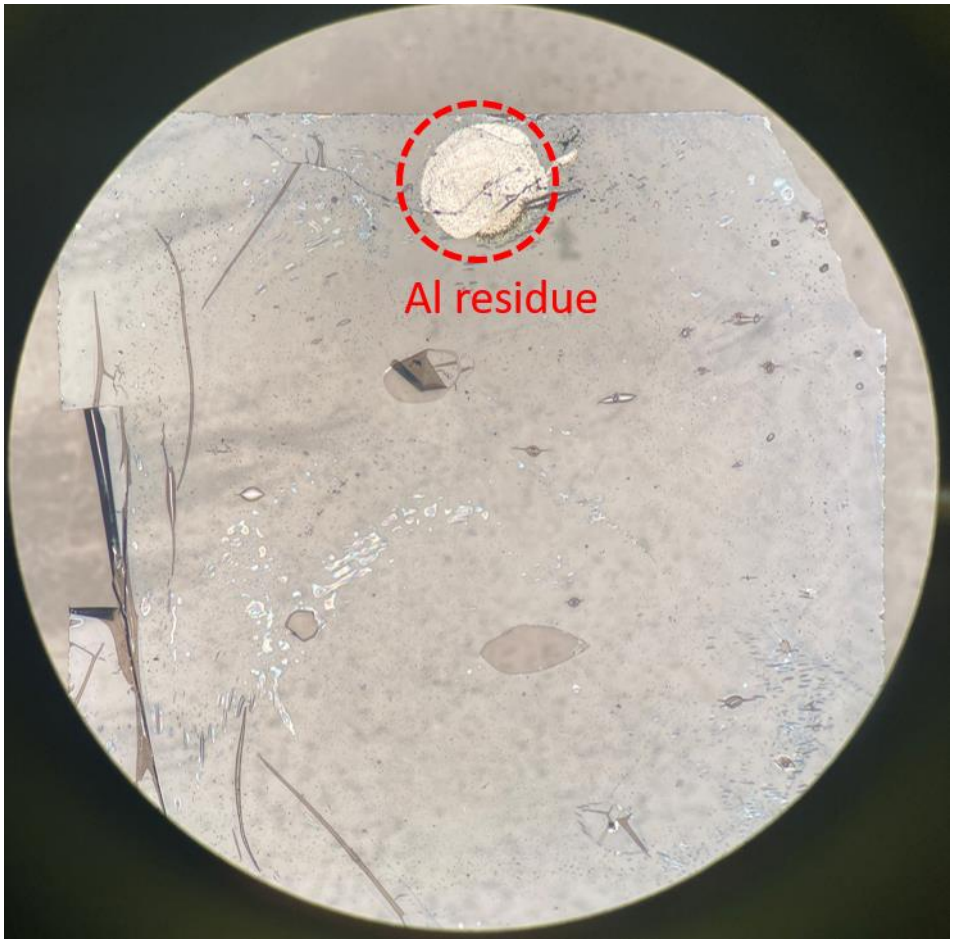

Figure S1. Optical image of the transferred AlN NM on the sapphire substrate. The red circle marks the region where the Al is not fully removed by RIE.

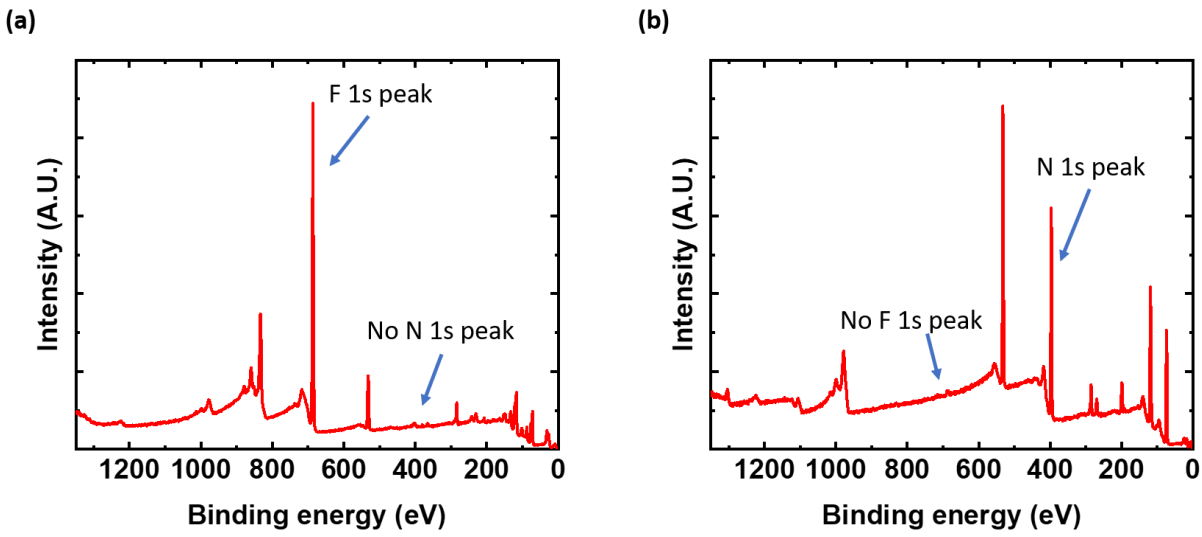

Figure S2. XPS survey spectra of the sample surface (a) right before Al removal and (b) after Al removal via RIE. The appearance of N 1*s* peak in (b) indicates that the AlN is exposed. Meanwhile F residue from the XeF_2 etching is observed in (a). And it can be removed by the RIE etching of Al.

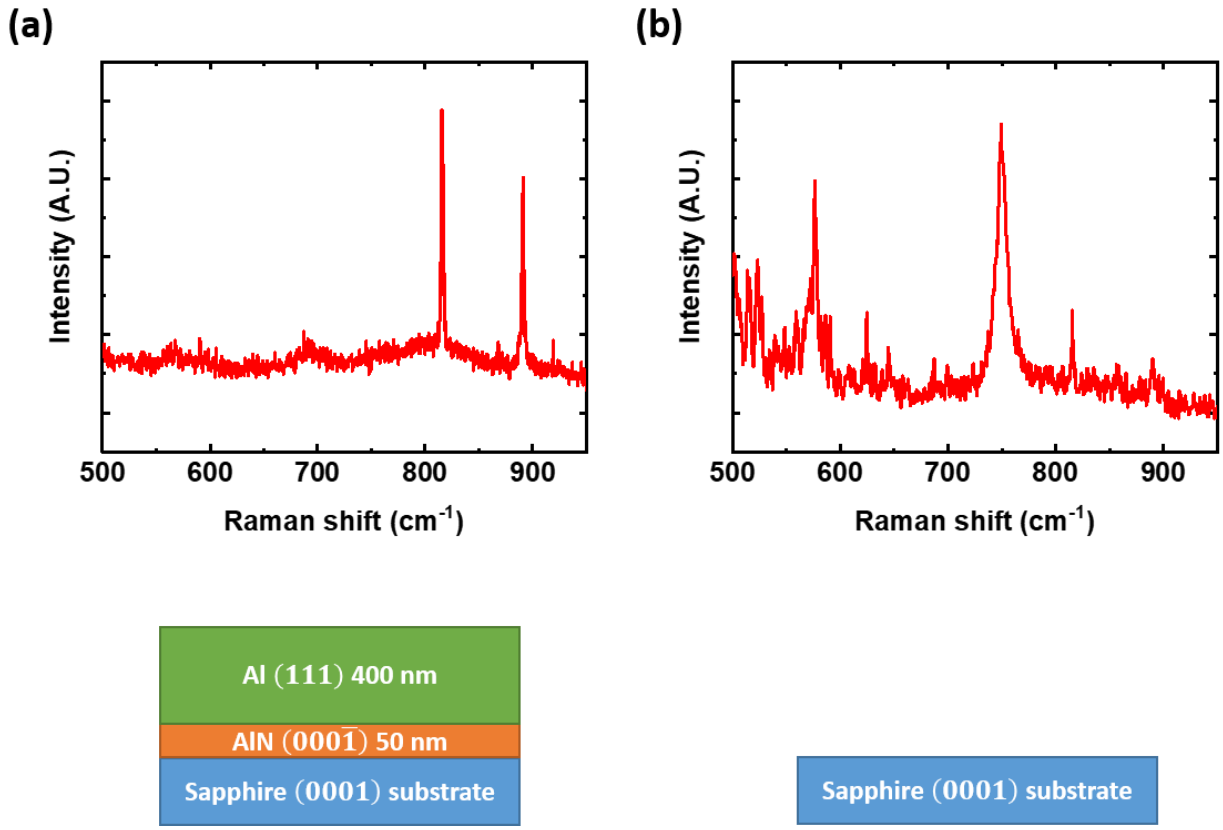

Figure S3. Raman spectra of (a) the transferred Al (111)/AlN (0001)/sapphire sample and (b) the sapphire substrate. The corresponding sample structures are drawn underneath the spectra.

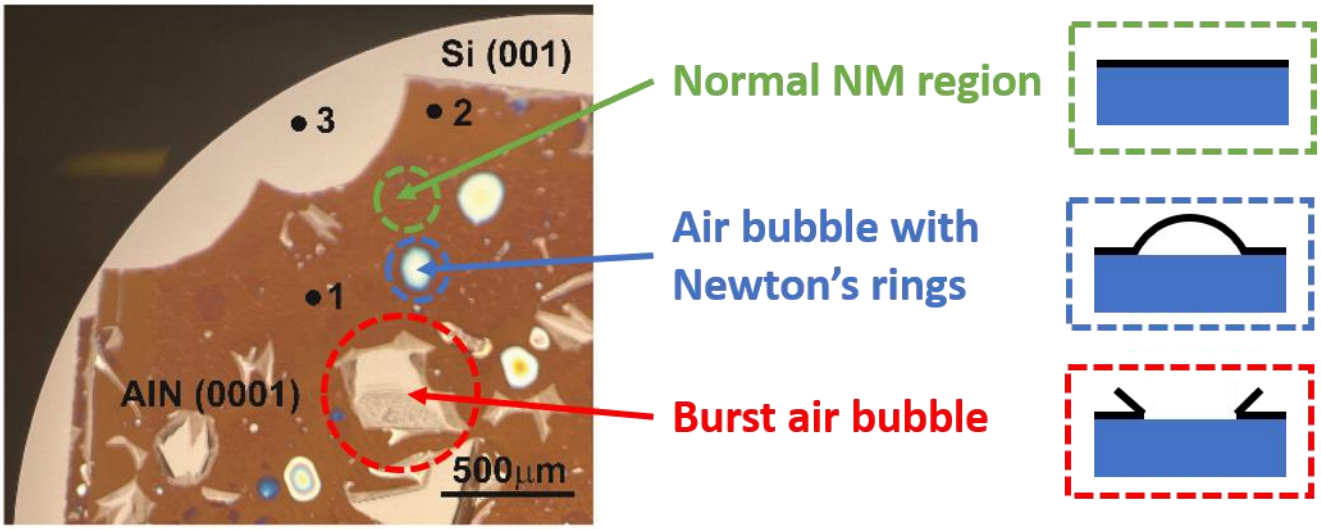

Figure S4. Optical image of the transferred AlN NM on the Si substrate with schematic illustration of various regions of the transferred NM. The sample has been annealed at 350 °C for 5 min in N_2 ambient via rapid thermal annealing (RTA) after the NM transfer.

The AlN NM was transferred to the Si substrate as a whole piece without any intentionally made breakage or holes. However, during the transfer process, air was trapped at the interface between the AlN NM and Si substrate. As a result, during the RTA process to form chemical bonding between the AlN NM and the Si, the air became localized and formed air bubbles. The large air bubbles burst during the RTA process. On the other hand, smaller air bubbles generated Newton's rings from light interference. These features are illustrated in Figure S4.

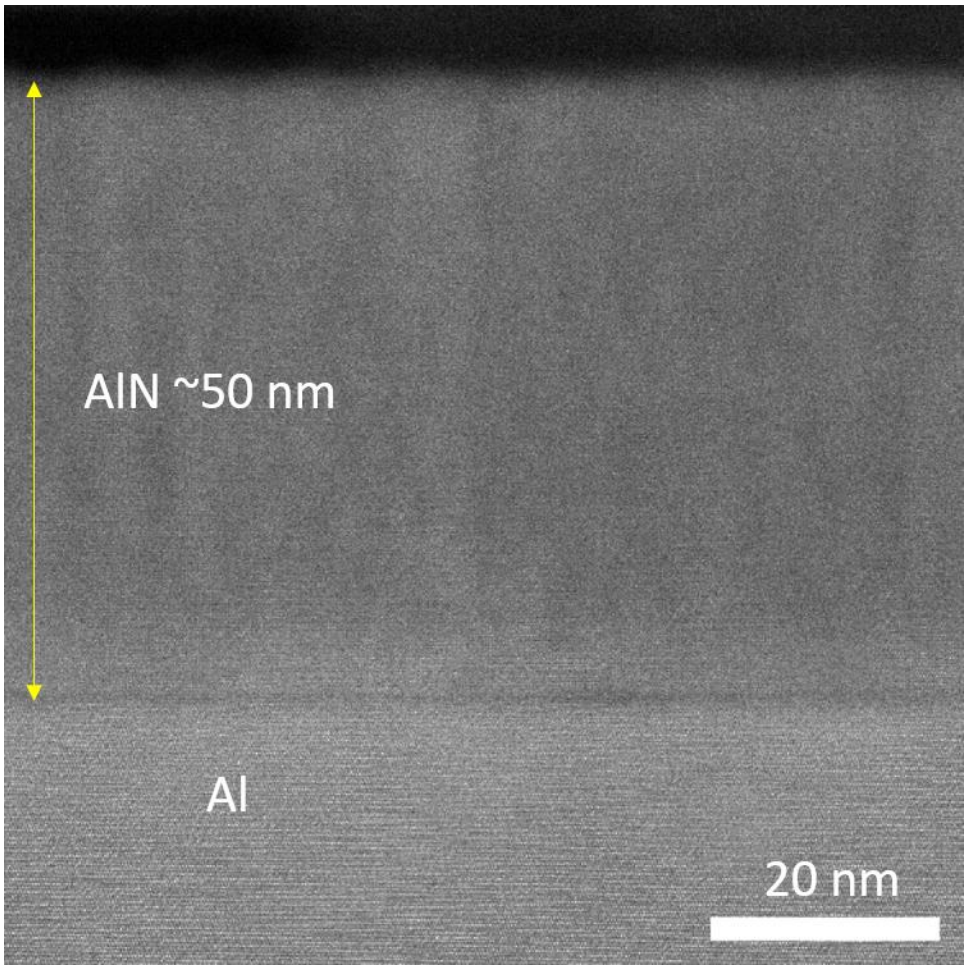

Figure S5. HAADF-STEM image showing a 50-nm-thick AlN grown on Al layer.

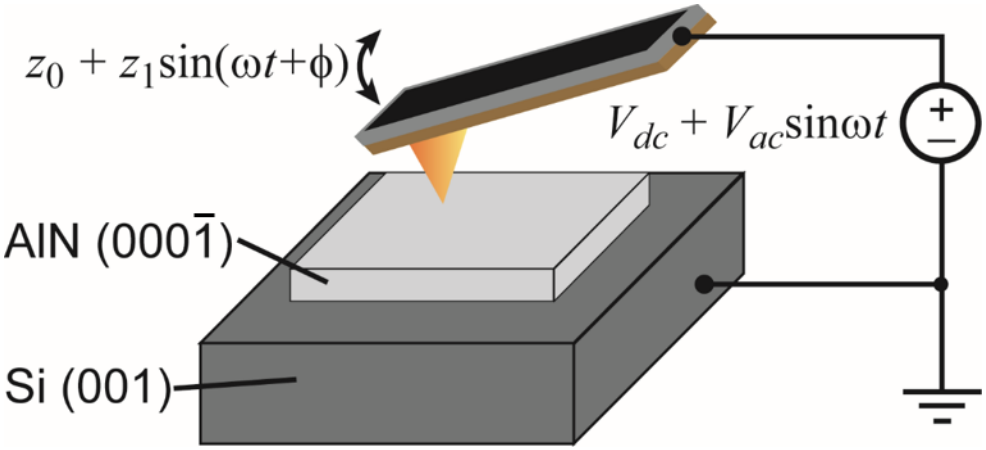

Figure S6. Schematic illustration of PFM measurement and sample geometry.