2D MATERIAL DETERMINISTIC STACKING EXPLOITING SCALABLE TRANSFER TECHNIQUES

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INTRODUCTION

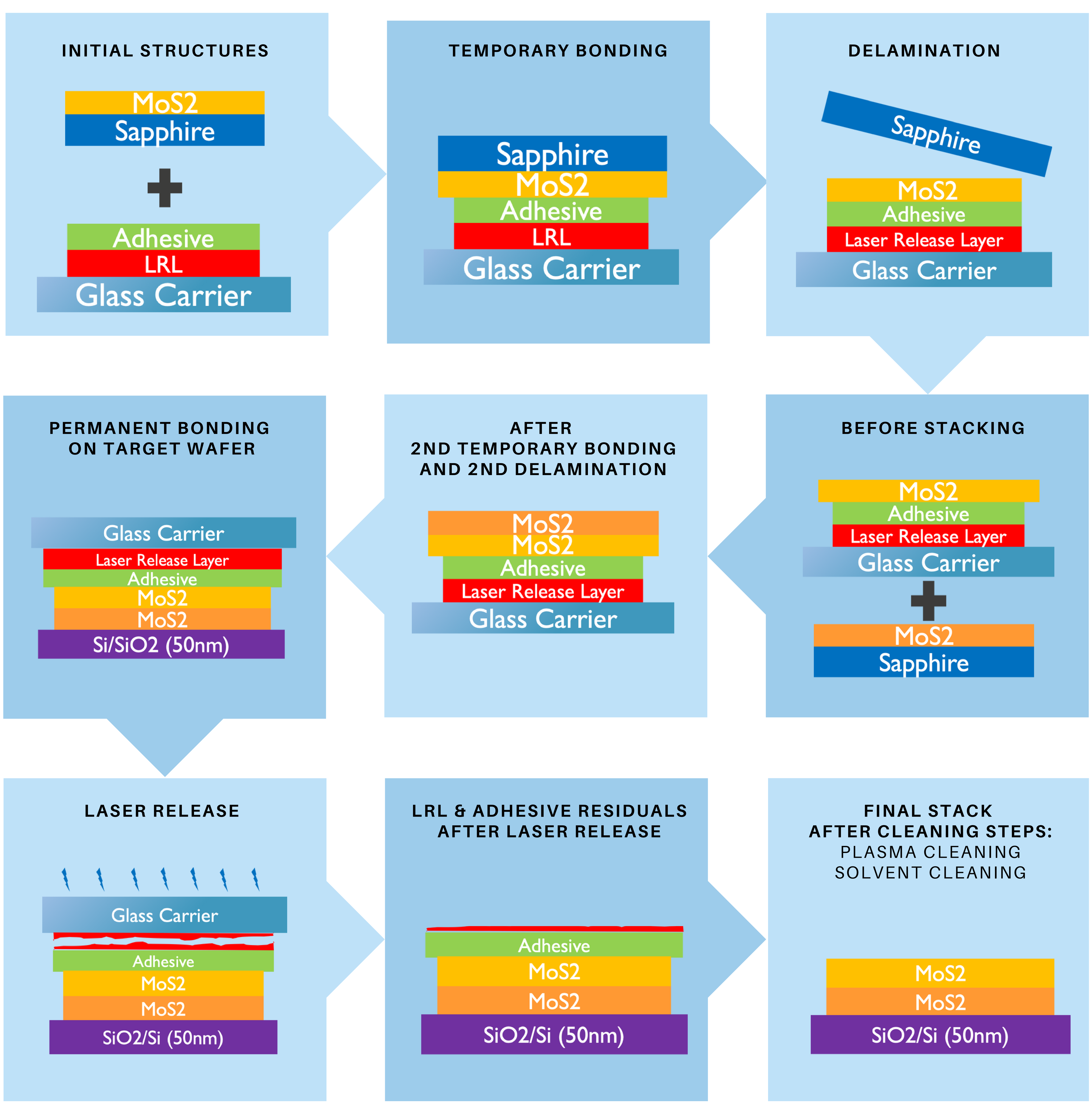
2D materials proved to be promising candidates in emerging electronic applications. Their properties enable novel applications like biosensing, catalysis or in the field of optical communications and even have the promise to enable further physical transistor scaling. [1]

One of the main challenges remains their integration in electronic devices with industry compatible processes. Most of the devices presented in recent literature are limited to the laboratory scale. To make those processes compatible with industrial production, different prerequisites must be satisfied: high quality and large-scale synthesis of the 2D materials, robust reproducibility, low temperature budget, and a relatively fast and cost-effective process.
The best approach to synthesise large scale and high quality 2D materials is epitaxial growth on a crystalline substrate, which is often not compatible with direct implementation in devices due to the temperature budget (direct growth methods). As the epitaxial growth is done on templated wafer a transfer process is required to relocate the 2D material on a target wafer.

METHODOLOGY

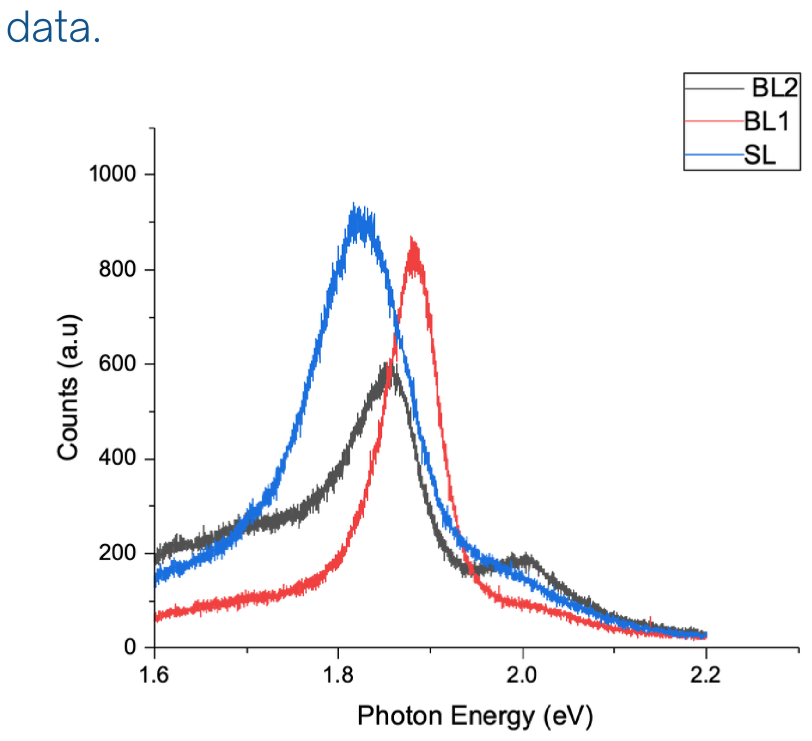
In this study we present a transfer process of epitaxially grown MoS2 on sapphire (Al2O3) wafers to SiO2 substrates. We have further obtained the deterministic stacking of two MoS2 monolayers controlling the twist angle (30 deg). Moreover, the temperature budget of the transfer process is lower than 300°C in all the steps and the process is realised at full 2-inch wafer scale with a process that allows further scaling to larger wafer sizes.

METHODS

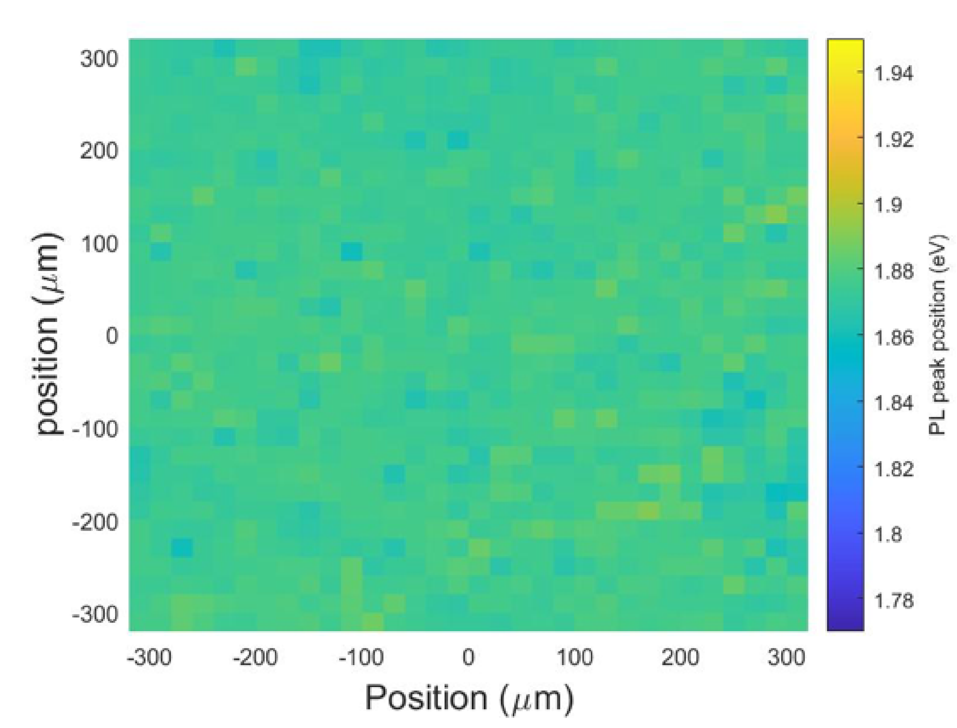


RESULTS

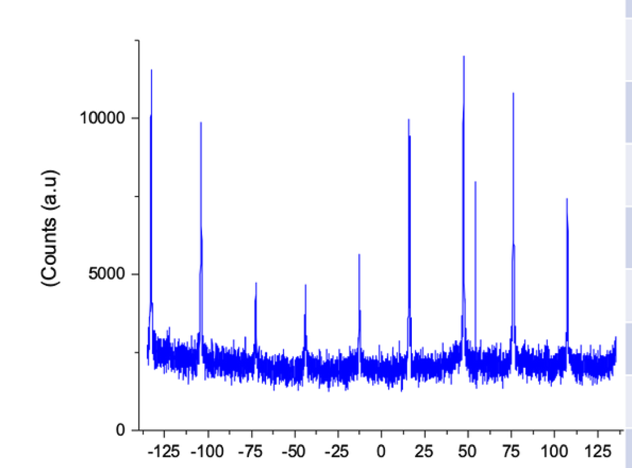
The PL spectra of the bilayer is consistent with other MoS2 stacked bilayers found in literature [2]. Moreover, the PL map shows how the proprieties are homogenous along the sample surface. The stacking angle obtained of 30 deg is confirmed by the XRD data.



PL SPECTRA OF THE TRANSFERRED STACK
BL1: BILAYER SAMPLE WITH FEW DEFECTS
BL2: BILAYER SAMPLE WITH DEFECTS
SL: SINGLE LAYER REFERENCE SPECTRA



PL MAP OF THE TRANSFERRED STACK (BL1)



Peak	Teta (deg)	Peak Distance
1	-132.79526 ± 0.0048	28.827
2	-103.96825 ± 0.00598	31.302
3	-72.66627 ± 0.01668	28.788
4	-43.87847 ± 0.01576	31.219
5	-12.65908 ± 0.01118	28.738
6	16.07999 ± 0.00509	31.246
7	47.32516 ± 0.00408	28.725
8	76.05042 ± 0.00505	31.271
9	107.3209 ± 0.00774	

IN-PLANE XRD DIFFRACTION PATTERN OF THE BILAYER

RELATED LITERATURE

[1] Akinwande D, Huyghebaert C, Wang CH, Serna MI, Goossens S, Li LJ, Wong HP, Koppens FHL. Graphene and two-dimensional materials for silicon technology. Nature. 2019 Sep;573(7775):507-518. doi: 10.1038/s41586-019-1573-9. Epub 2019 Sep 25. PMID: 31554977.
[2] Probing the Interlayer Coupling of Twisted Bilayer MoS2 Using Photoluminescence Spectroscopy
Shengxi Huang, Xi Ling, Liangbo Liang, Jing Kong, Humberto Terrones, Vincent Meunier, and Mildred S. Dresselhaus
Nano Letters 2014 14 (10), 5500-5508
DOI: 10.1021/nl5014597

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