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Prof Zdeněk Doležal
Vice-Dean of Fac. Math. Phys., Charles University.

11 Sep. 22

Dear Professor Doležal,

I have read and evaluated the Habilitation thesis "Epitaxial Graphene on Silicon Carbide" by Dr Jan Kunc. My assessment is summarised below.

The Habilitation thesis presented to me consists of an introduction, 5 chapters, a list of author's publications, and a conclusion over 65 pages. Additionally, 15 original papers co-authored by Dr Kunc are annexed.

Brief Introduction provides an overview of Dr Kunc's personal journey in the field of graphene and acknowledges the many scientists who influenced his path. The introduction is succinct but allows the reader to quickly place what follows in historical and geographical contexts.

This line continues in Chapter 1 which presents a brief history of graphene. This is not a mere list of facts and dates. The history of graphene has seen plenty of drama and strong personalities. It is easy to become opinionated depending on what your own research is about or who you learn your trade from. Dr Kunc navigates the reefs very skilfully. His narrative is very balanced and at the same time very clear in the sense that he makes his views on the history known without appearing judgemental.

Chapter 2 continues with derivations of basic electronic and optical properties of graphene. Although well known and frequently taught in physics courses around the world, the right-up presented in the thesis is pedagogically sound and can readily be presented to students in lecture notes. I would have liked perhaps to see certain remarkable consequences of the Dirac spectrum of electrons in graphene to be emphasised to students a bit stronger. For example, the quantum Hall effect at room temperature. A simple comparison of energy scales with numbers for graphene and conventional 2DEGs would be instructive. But fair enough, there is a reference to the original experimental paper and an inquisitive student will dig it out. I found the section discussing common misconceptions regarding graphene very useful and this spans both fundamental properties and applications. And of course I was pleased to see the resistance standard being duly acknowledged as real-world application. As a clarification which should not be taken as criticism of the author at all, I don't think I

was really 'worried' about the term epigraphene as suggested in the thesis; rather I proposed to make an effort and include it in the standard vocabulary as defined by ISO/TS 80004-13:2017 to promote this term. In the meantime I use it myself, ref 126. Disappointingly, I found a surprising number of typos (remaing, missleading, countour, definiton, eigenfunctin, perimittivity, to name a few) where a spellcheck would do, and an annoying lack of capitalisation in the term Hamiltonian throughout (see for example here).

Chapter 3 is a short overview of methods of graphene fabrication. It is well written, although an illustration would perhaps be appropriate along the lines of figure 2 in the review by Wang, Narita & Müllen. I would perhaps expect to see the reduction of graphene oxide in this context, not least since the source material is extensively mentioned in Chapter 1, including figure 1.1 where it is shown to surpass CVD and epigraphene on the number of publications. On the other hand, I found the discussion of decoupled graphene flakes on graphite surface in section 3.2 very interesting, and I was not aware of ref 128. Another aspect of graphene that can excite and motivate students, so very appropriate. Brief description of alternative fabrication methods, their pros and cons, places the central and more detailed discussion of epitaxial graphene on SiC in proper perspective. It describes both perceived weaknesses, such as the cost, and advantages, such as the scalability. Properties, for example the career mobility, are put in the context of fabrication. Some details are discussed somewhat superficially, but still with sufficient rigour (at times, even with excessive detail, for example where the role of remote phonon scattering is described).

Chapter 4 is dedicated to graphene allotropes (the latter spelled with a typo). I am not entirely sure if different types of epitaxial graphene can properly be called allotropes (in the same sense as graphite and diamond are both allotropes of carbon), but happy to accept that this is one way to differentiate epigraphene from, say, exfoliated graphene. This would make an interesting topic for discussion with students as well. The description of the buffer layer, epigraphene proper, properties of intercalated layers, multilayer graphene, as well as 1D (fabricated top-down or bottom-up) and 0D structures is technically and pedagogically sound. This chapter nicely illustrates the author's ability to explain complex physics such as the Landauer formalism for transport in ballistic nanowires, figure 4.6, in simple and accessible terms.

The final Chapter 5 is dedicated to Dr Kunc's own significant and multifaceted contribution to the field. The breadth of topics covered in his research on epigraphene is impressive and his personal contribution to collaborative papers also demonstrates a remarkable set of skills. Importantly, PhD and early-career scientists under his supervision also develop into excellent researchers as evidenced by the attached papers. Last but not least, much of the presented work was carried out in the group he started on return to Prague. This shows leadership skills and aptitude for highest quality independent work and not only in his career-defining topic of epigraphene, but also beyond.

In summary, the thesis presented to me, minor deficiencies aside, is of high quality. In my opinion Dr Kunc has demonstrated the necessary level of scholarship, teaching and leadership aptitude to fully deserve Habilitation.

My degree of confidence in the assessment is high. I consider myself an expert in graphene, epigraphene in particular, having published nearly 40 papers in this field alone cited over 1500 times. I lead a large department at the UK's National Physical Laboratory with about 100 researchers. As a professor of Physics at Royal Holloway, University of London, I also teach undergraduate courses and supervise PhD students.

I can confirm that a high percentage of coincidence in the plagiarism check is an artifact of the Turnitin system as it includes appended papers compared with their identical published version.

Yours sincerely,

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Head of Science - Quantum Technologies