

Identifying Product Life Cycle Stage of Hard Carbon Anode Materials

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Introduction

Hard carbon materials

- Non-graphitizable, disordered carbon material¹
- Promising and potential sustainable anode material for different batteries and fuel cells
- Large benefit to be applied in fast-charging, stationary storage, heavy vehicles due to high power density and charge rate¹
- Derived from biomass, organic waste and polymer²
- Potentially lower energy demand and lower negative environmental impact than synthetic graphite³



Research objectives

To estimation the global production and identify the product technological life cycle stage of the emerging hard carbon anode material

Approaches

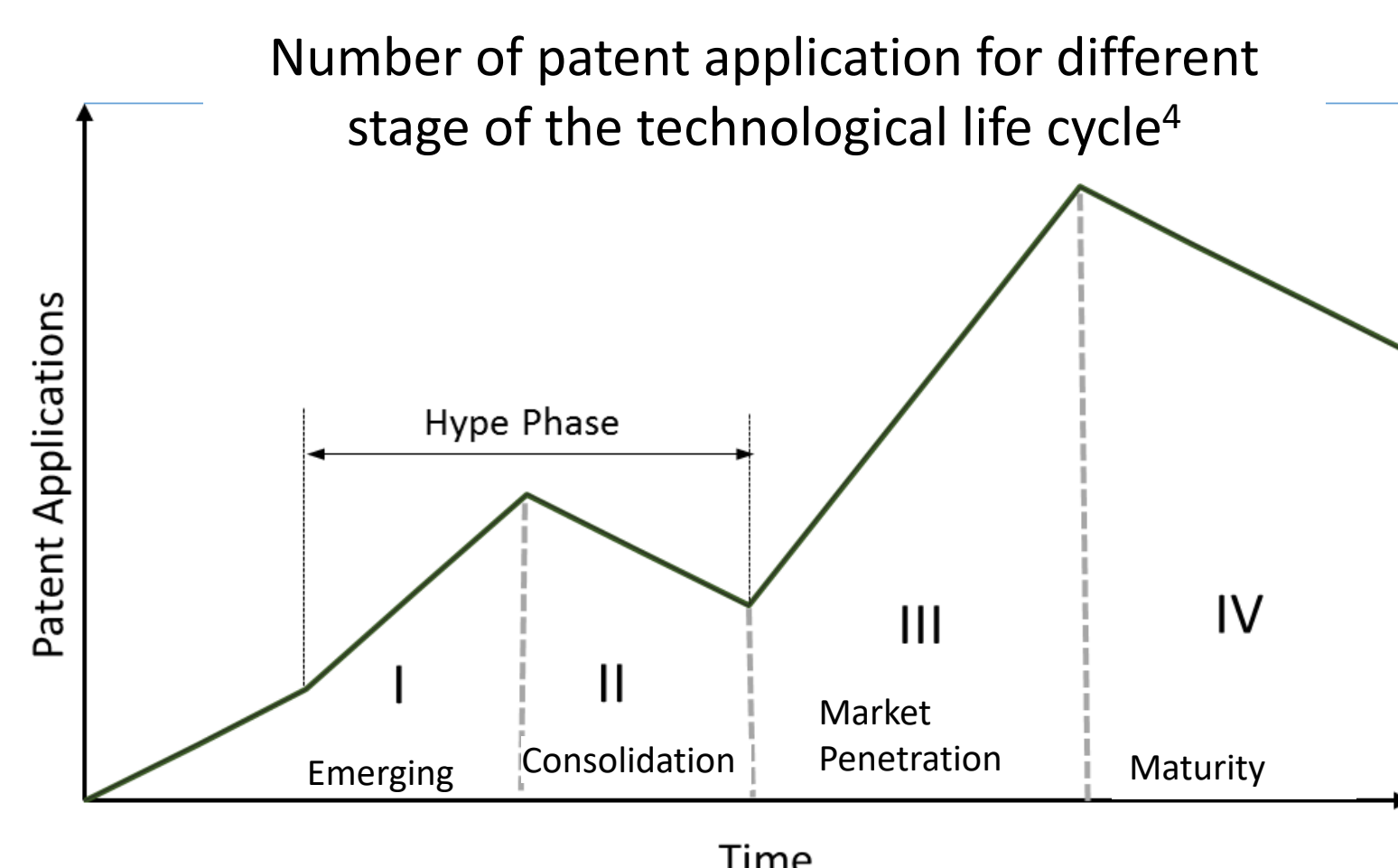


Stakeholder's interview

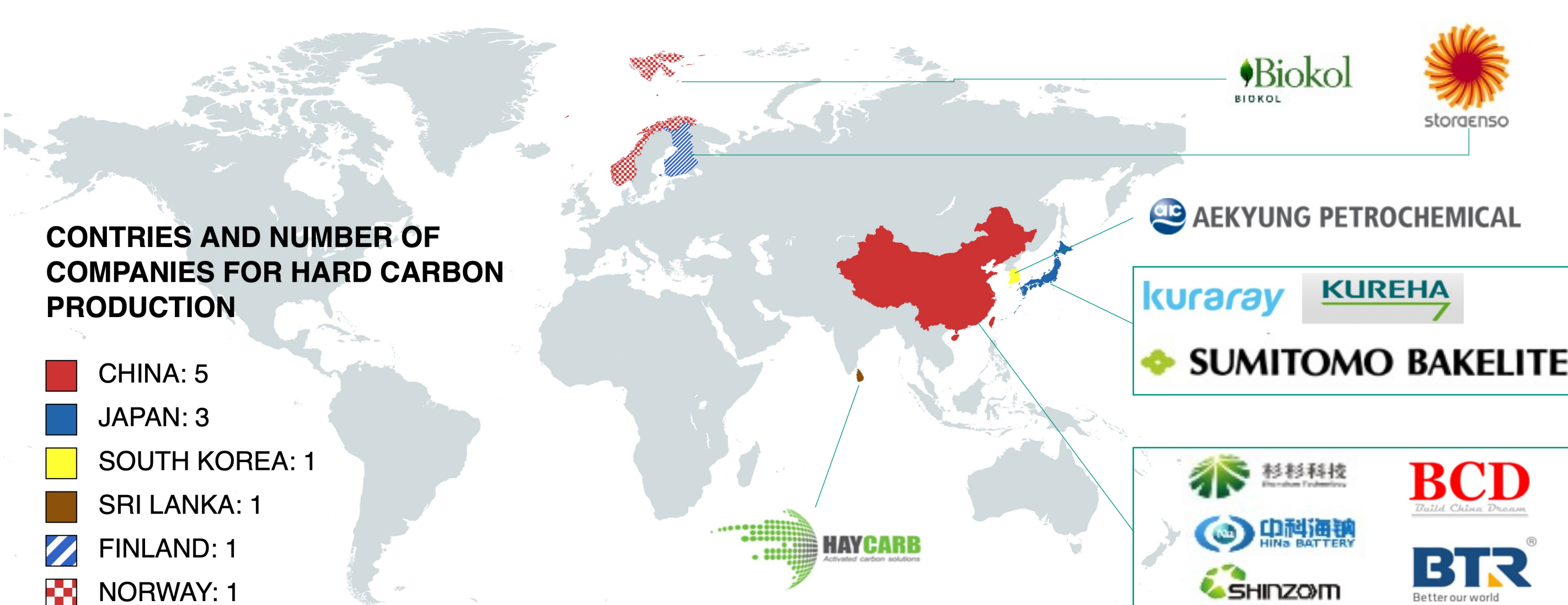
- Industry: producers and suppliers of hard carbon materials understand the current market situation and development
- Technology developer: scientists in laboratories know the edge-cutting research of hard carbon material and can offer data and information found in experiment

Patent analysis

- Based on EPO OPS (European Patent Office database through their Open Patent Services), a patent crawler and analyze tool⁴ was applied
- Patent activity can reflect the R&D expenditures in technology
- Four stages of the technology life cycle (TLC) are identified



Global Production

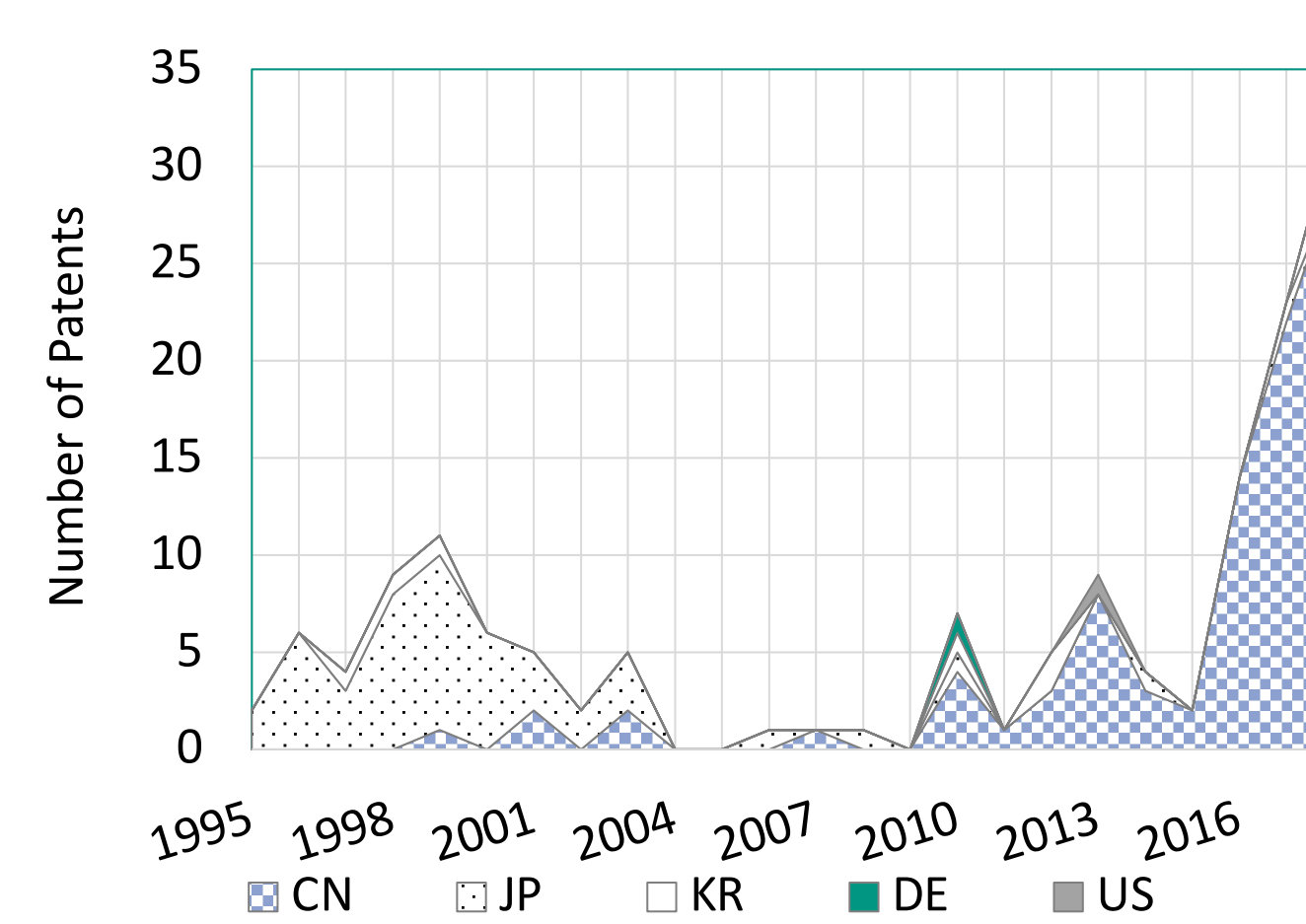


- Production capacity and supply of hard carbons are mainly located in East Asia, such as China, Japan, Korean and Sri Lanka
- Although most Chinese graphite manufacturers are able to produce hard carbon, capacities are not significant due to insufficient demand and low market maturity
- Japanese companies has accumulated experience for producing hard carbon in industrial scale for over 15 years, the production capacity of Japanese companies are overall higher than Chinese companies
- European producers are emerging in these 3 years, coming with their focus in the biomass precursors. The reason of this emergence lies in the development of sodium-ion battery and the lack of local hard carbon production

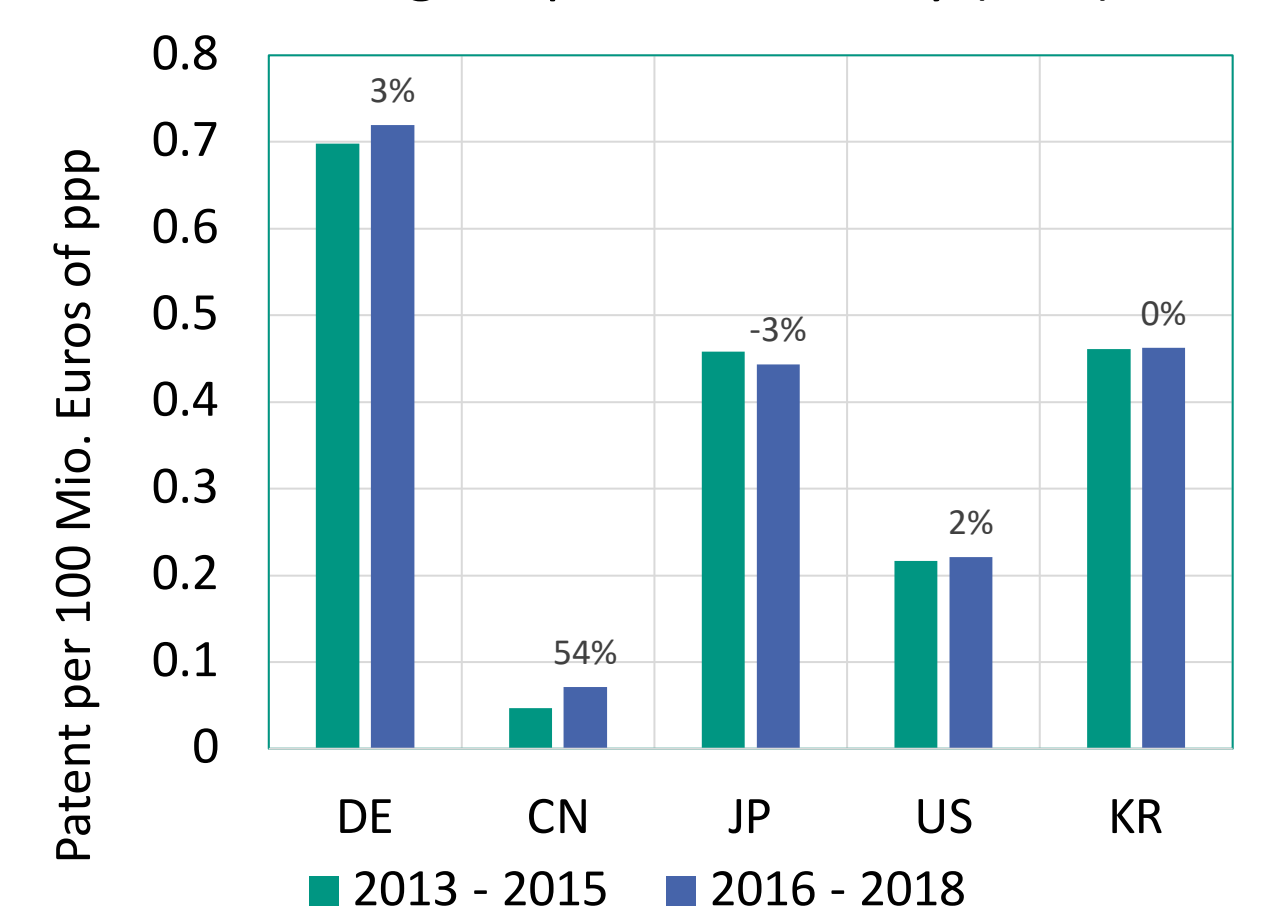
Patent Analysis

- 5 most active countries are identified for the period 1995-2018: Germany (DE), China (CN), Japan (JP), Korea (KR), and US (United States)
- 229 patent results from search term: hard carbon + anode/electrode + battery

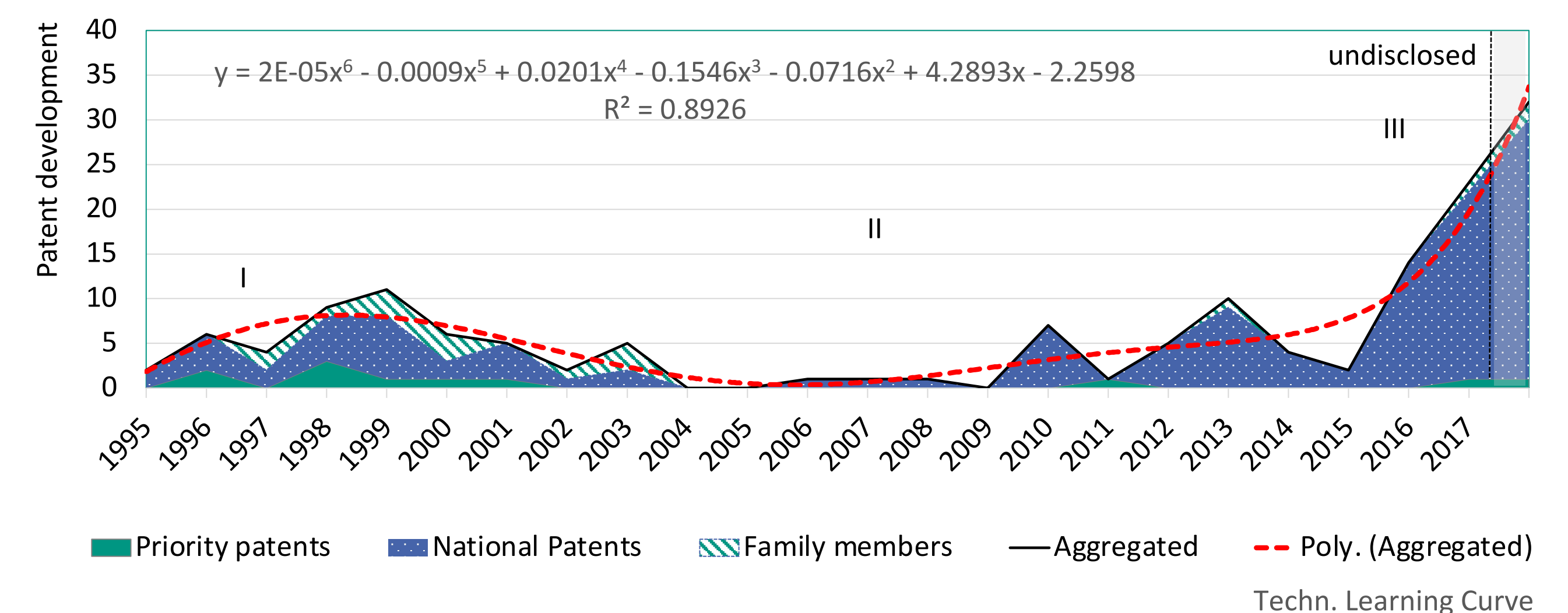
Patent activity of different countries analyzed for hard carbon materials



General patent intensity in regard of GDP (PPP) per country per 100 Mio. Euros and change in patent intensity (in %)



Technological life cycle stage of hard carbon anode materials are approximated (4th-degree polynomial regression) based on the yearly published number of all patents



Discussion

- The result of patent analysis is overall in line with the literature review and stakeholder's interview
- Comparing the industrial production and patent activities, it shows that patenting activities in Japan, China and Korea has ben translated into market to a certain extent. However, it is not the case for Germany.
- Considering the economic growth and development status of analyzed countries, the intensity analysis illustrates that Germany has a very high patent intensity. At the same time, china shows a high increase of 54% of patent intensity, while other countries present only a small increase or even decrease
- The approximated technological life cycle analysis draws a development picture and identifies that the hard carbon material is penetrating the market
- Information gathered by stakeholder's interview and literature review draws a picture of global production and shows that the market of hard carbon exists but still not mature, which is consistent with the TLC results

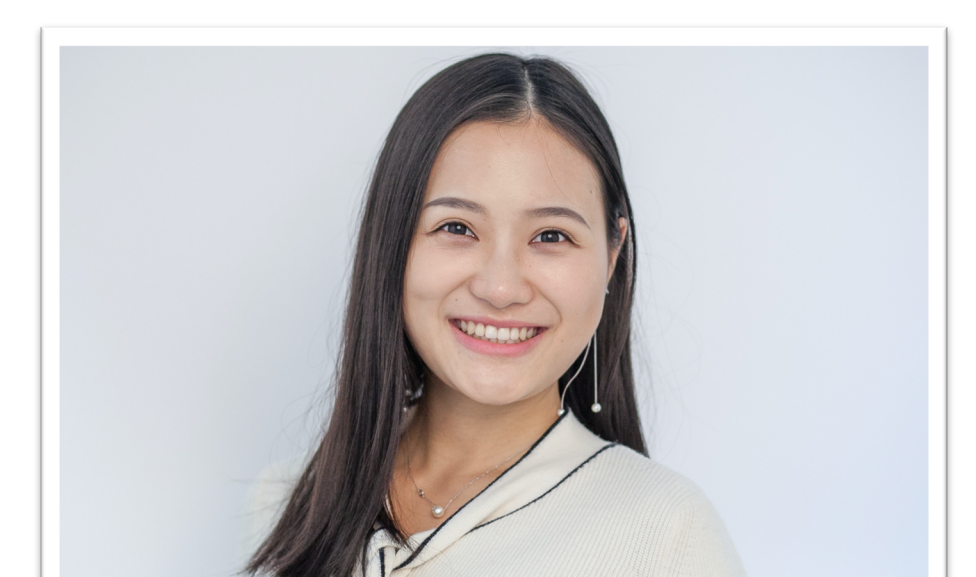
Take Home Message

Hard carbon, as a promising anode material for batteries, is identified as a market-penetrating product and under a rapid development period. Higher patent activity, e.g. in Eastern Asia, is a contributing factor for their knowledge accumulation and high local manufacturing capacities.

Contact

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Reference

[1] X. Dou, 2018. Dissertation: Hard carbon anode materials for Sodium-ion Battery [3] C. Liedel, 2020. Sustainable Battery Materials from Biomass. In: ChemSusChem 13 (9), S. 2110-2141; [3] J. Peters, M. Abdelbaky, M. Baumann, M. Weil, 2019. A review of hard carbon anode materials for sodium-ion batteries and their environmental assessment. In: Matériaux & Techniques 107 (5), S. 503; [4] M. Baumann, T. Domnik, M. Haase, C. Wulf, P. Emmerich, C. Rösch, P. Zapp, T. Naegler, M. Weil, 2021. Comparative patent analysis for the identification of global research trends for the case of battery storage, hydrogen and bioenergy. In: Technological Forecasting & Social Change 165 (2021) 120505

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