Research into Soft Magnetic Composites

1.1 Inroad inductive power transfer (IPT) to charge EVs

Inductive power transfer (IPT) has been proposed as a possible tool to increase usage of electric vehicles (EVs) by improving user-friendliness– removing the hassle of cables and mechanical connections, and increasing their practical range – with widely spatially distributed charging. In New Zealand, the Ministry of Transport's (MoT) latest electric vehicle projections (2017)[1] expect EV fleet numbers to at least double every year to reach 64,000 EVs by the end of 2021 and will make up 40% of the total vehicle fleet by June 2040. This estimate is in line with global estimates, with Bloomberg expecting EVs to account for 54% of sales by 2040 [1,2]. Infrastructure to support this growth, or accelerate the technology's acceptance, are not deployed as yet.

1.2 Soft magnetic composite (SMC) materials for inroad IPT system

Current IPT systems typically use ferrite materials to improve magnetic coupling which are particularly suited for inductive applications operating between 10 to 500 kHz [3,4]. Although ferrite is optimal for guiding magnetic fields, it is very brittle and would not survive within a road structure. Non-brittle and affordable magnetic materials are required so that vehicles can run over charging pads built into the road without destroying them. This requires innovative solutions and new magnetic material sources to meet these needs in an economically viable way.
A potential way is using soft magnetic composite (SMC) materials in which a magnetic filler is mixed into a matrix to arrive to an optimum between economic viability and the material's mechanical, thermal, and magnetic properties. SMC materials have a critical role in power electronics, enabling highly performant inductors, transformers, inverters, and other inductive devices [5]. These materials have been extensively studied over the past 50 years resulting in a wide range of materials with properties optimised for given applications.

The Wellington-based team (Figure 1) are investigating the best soft magnetic composite (SMC) for in-road charging. So far this includes incorporating NZ ironsand (Figures 2 & 3) as a component [6]. NZ ironsand offers a magnetic permeability of 1-5 which is at the lower end of the commercial SMC materials however could be combined with other materials to provide a viable and affordable magnetic material robust enough for inroad charging systems. Ongoing work continues to determine the best SMC mix (magnetic material + binder) (Figures 4-7).

Figure1: Wellington-based team.

Figure 2: Magnetically separating the magnetic component out of iron sand.

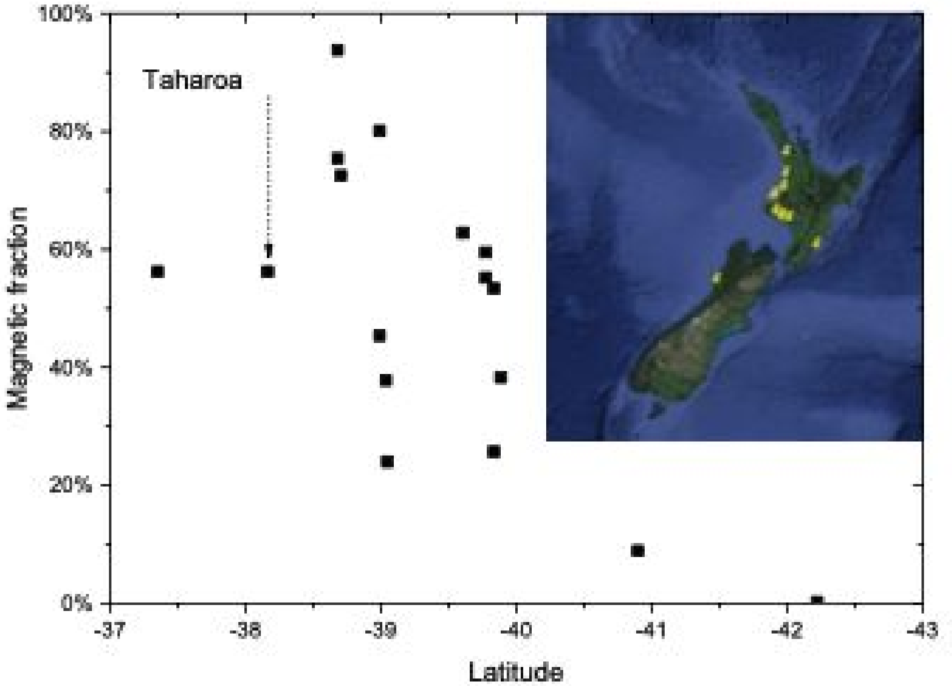


Figure 3: Iron sand sample locations and their magnetic fraction.

Figure 4: MC40 magnetic concrete samples.

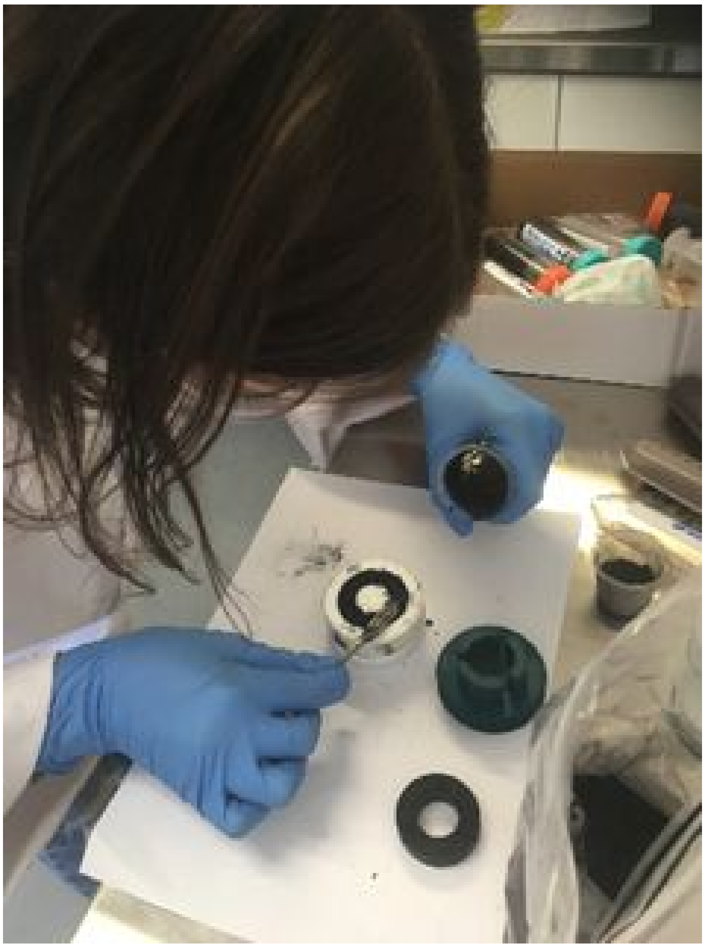


Figure 5: Making new SMC mixes of magnetic material and binder materials.

Figure 6: Measuring magnetic permeability (Low field measurement with LCR meter).

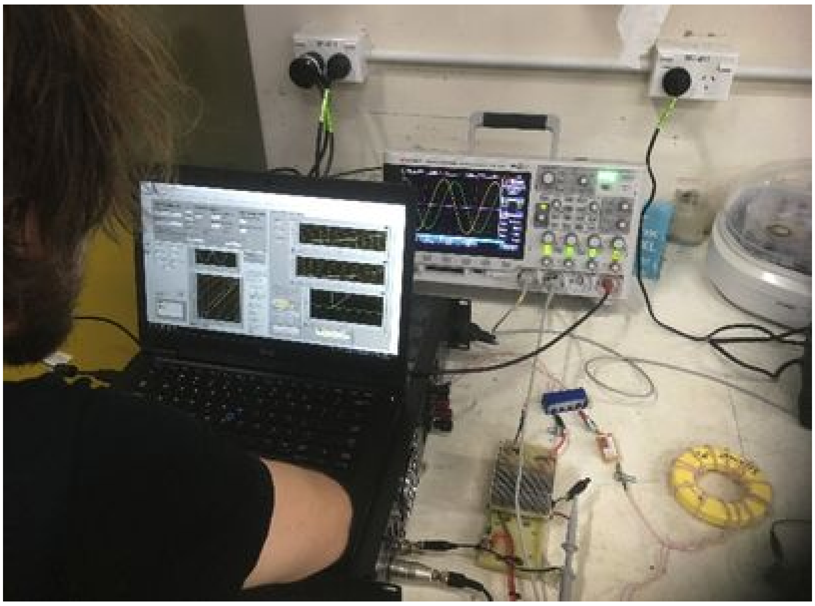
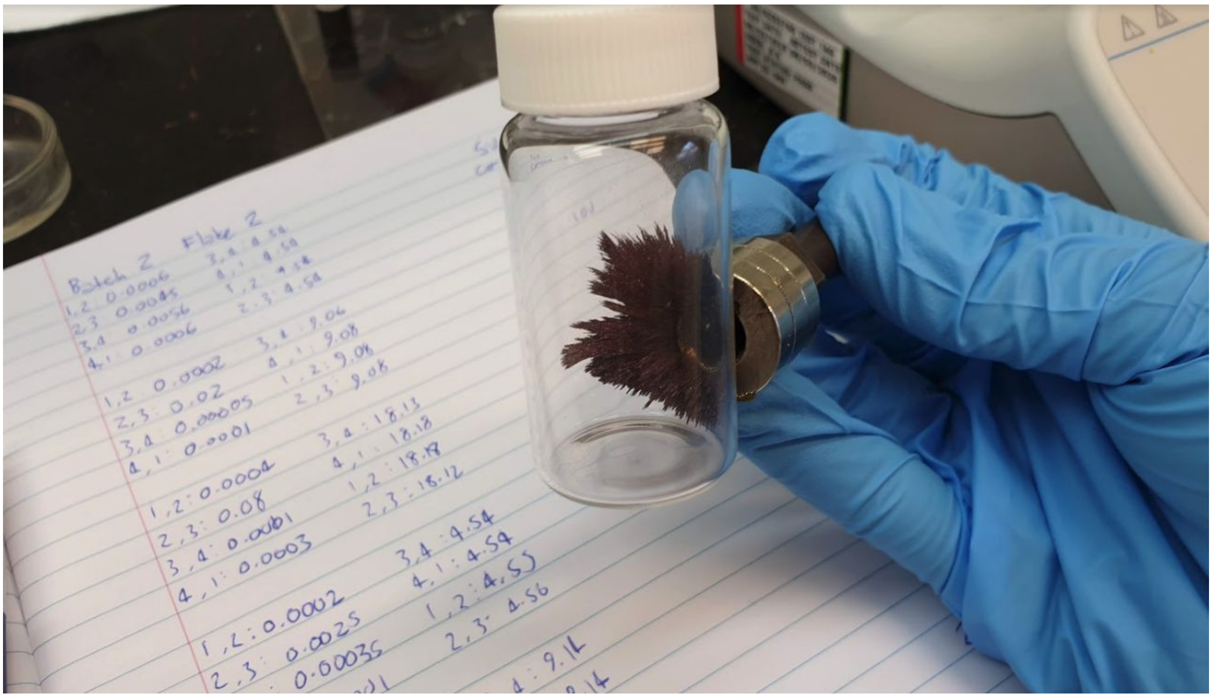


Figure 7: Measuring magnetic permeability (Transformer setup).

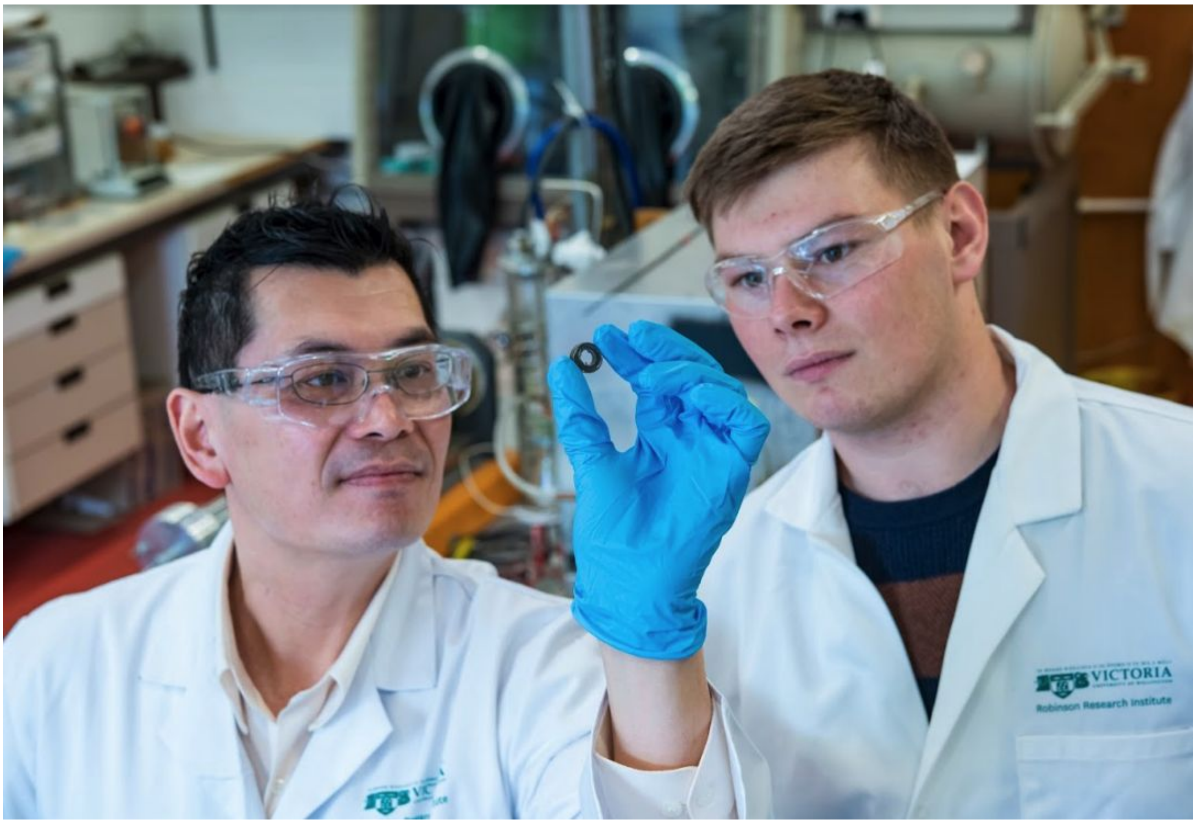
References

1. Ministry of Transport, Electric Vehicles Programme, http://www.transport.govt.nz/ourwork/climatechange/electric-vehicles/
2. https://about.bnef.com/electric-vehicle-outlook/#toc-download
3. G. A. Covic and J. T. Boys, “Modern trends in inductive power transfer for transportation applications,” IEEE Journal of Emerging and Selected Topics in Power Electronics, 1(1) 28–41 (2013)
4. B. Park, J. Park, Y. Shin, C. park, S. Ahn, I. S. Han, “Wireless Charging System Using Soft Magnetic Composite for Unmanned Aerial Vehicle”, International Journal of Communications, 2 59-62, (2017)
5. O’handley, Robert C. "Soft magnetic materials." Modern Magnetic Materials (2000).
6. Trompetter, W.J., Leveneur, J., Kennedy, J., Rumsey, B., McCurdy, M., Chong, S., Long, N., “Investigation of New Zealand's natural magnetic minerals for application in inroad charging systems (2019) International Journal of Modern Physics B, art. no. 2040018, DOI: 10.1142/S0217979220400184

More images



A sample of oxidised and coated Vitroperm. For use in a soft magnetic composite (SMC) which will go for magnetic testing.



Shen Chong and Fergus Robinson admire a Vitroperm SMC sample toroid, for magnetic measurements.

A Vitroperm sample for use in SMC materials

LN2 being used to cool a diffusion vacuum pump for VSM Measurements.