and lung-cancer treatment with microwave ablation.

About the author

Markus Dingeldein, pioneer and expert in microwave technology, looks back on many years of experience in the company. Over the past 27 years, the electrical engineering graduate has held various management positions in operations and sales, most recently heading the global sales organization. In the future, he will drive further internationalization.

Ricky's Afterthought:

Processing of plastic waste revisited

A.C. (Ricky) Metaxas

Life Fellow St John's College Cambridge UK
Email: acm33@cam.ac.uk

We use plastics at an accelerated rate. It is everywhere, packaging in shops and in industry, in hospitals and at home. The simple fact is that we cannot do without it and searching for alternative materials can be counter-productive because of the obvious benefits of plastics. However, the numbers are staggering. A recent report quotes that 400 Mt (million metric tonnes) of plastics are produced annually with Americans having generated some 220 kg per person in 2019 while the equivalent figure in Europe was 121kg. So it is evident that we have to manage this amount of plastic and after use not to damp it in landfills or in the sea which has adverse effect in marine life and its ecosystem.

By far the most used plastics are high density and low density polyethylene followed by polypropylene and polyvinyl chloride. Other plastics include polystyrene and polyethylene terephthalate are used to a lesser extent.

Back in the early 1980's when the "Yellow Bible" was published I wrote in Chapter 11 on Industrial Applications that pyrolysis using microwaves had been studied and specifically on page 312 microwave pyrolysis of coal in a discharge.

This Newsletter has on numerous occasions highlighted the work that emanated from the Chemical Engineering Dept at Cambridge University using high power microwaves for pyrolysis of a variety of plastic waste. This work has culminated in the company Enval which currently specialises in the processing of aluminium/plastic laminates in an applicator in the presence of carbon which acts as a catalyst absorbing the microwaves and imparting the energy to the laminates. Plastic laminate is lightweight and is preferred to other designs as it is flexible and protects the contents from oxygen, water and light. The amount of laminates that have to be processed in the UK is a staggering 160000 tonnes used in packaging of fruit juices, cosmetics and toothpaste.

The latest information is that SAIREM is supplying the magnetrons to power the propriety system. A typical Enval plant operates at a feed rate of up to 350 kg per hour, which roughly means it can process up to 2000 tonnes per annum. They collaborate with Kraft Heinz and Sonoko in the USA to investigate methods of plastic recycling and processing of the huge waste discussed above.

I am not suggesting that this is easy to achieve as I am aware that a lot of effort went into the various designs at the early stage culminating in the present system.

Conventional recycling still uses the process of pyrolysis to break down the waste to its molecular constituents by raising the temperature to hundreds of degrees C in a processor powered by gas. The main product is oil which can be refined to produce fuels or feedstock or indeed to produce more plastic. ExxonMobil announced that it was funding 13 chemical recycling units in the US capable of recycling 454000 tonnes of plastic by 2026.

I am aware that chemical recycling is not a term to be used often, as it conjures toxicity so an alternative way of expressing the same process is "advance recycling".

We must avoid just processing of waste using chemical recycling. A paper reviewing microwave pyrolysis was published recently advocating its advantages in view of diminishing fossil fuels and more to the point their escalating costs [1].

The question I am posing here is the following: with such vast amounts of plastic waste to be processed and with wholesale gas prices gone through the roof, could assisted microwave pyrolysis be once again considered by other AMPERE R&D centres in Europe as an alternative to considering conventional or advanced recycling?

For further reading

1. Review of microwave pyrolysis as a sustainable plastic waste management technique", Putri Humairah Monashofian Putra, Shaifulazuar Rozali, Muhamad Fazly Abdul Patah and Aida Idris, Journal of Environmental Management Available online 12 Dec 2021

Worldwide news in brief in the energy sector

*I hear that the first CO_2 to methanol plant has been commissioned in China. The plant uses 160000 tonnes/annum of CO_2 and produces 110000 tonnes/annum of methanol which is used as a feedstock.

*The EU commission is putting forward emergency regulation to fast track the deployment of renewable energy so that to reduce the reliance on Russian oil and gas. This will have the effect of accelerating the granting of permits and thus reducing the time for starting to build these projects.

*The first phase of a green hydrogen plant in Egypt has been commissioned and is financed by Fertiglobe, a strategic partnership between ADNOC (Abu Dhabi national Oil Company) and OCI (a producer of natural gas fertilizers and industrial chemicals) but also includes Egypt's sovereign fund. Fertiglobe is the largest seaborne exporter of urea and ammonia combined and based in Abu Dhabi, UAE. When fully operational it will deliver 150000 tonnes of Hydrogen, using its 100MW electrolysers powered by a combination of wind and solar power to the tune of 260 MW (see Newsletter Issue 107 June 2021)

*A company founded by Bill Gates in 2008, TetraPower concluded a $830m private equity raise for building a sodium fast reactor combined with a molten salt energy storage system, through its so called Natrium system. It will provide clean energy which can be very easily integrated into the power grids. Of course, it is worth stating that, when the reactor needs to be decommissioned the problem of storing the radioactive waste fuel remains.

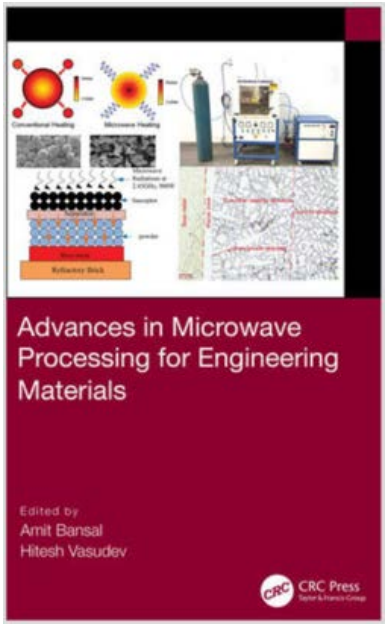
*Further to my Afterthought article in Issue 111 on the prospects of Nuclear Fusion: The Holy Grail of the Energy Crisis, the Financial Times in the UK first reported in mid Dec 2022 that 192 lasers fired their energy into a cylinder, its inner surface coated with gold. X-rays are emitted into the volume blasting a tiny pellet causing it to implode, compressing and heating up. This experiment was carried out at the National Ignition Facility at the Lawrence Livermore National Laboratory. This resulted in the release of 3.15 MJ of energy by using only 2.05MJ of laser energy to heat the fuel which was less than the diameter of a human hair. To put these vast energies into perspective the difference, 1.1MJ, is equivalent to 0.306 KWhr, a little over that which is needed to boil a kettle of water!

So the scientists claimed that for the first time more energy is released than used to produce a fusion reaction and hailed by many scientists working in this field as a tremendous breakthrough. As I understand it in this pulse-type experiment, the lasers

were fired for 100 trillionth of a sec or 10^{-10} s generating huge powers. Another aspect which has to be taken into account is the efficiency of producing the 2 MJ of laser energy bearing in mind that it required 300 MJ of input energy to get to that level of laser energy. Simply put, the lasers used were very inefficient. So this result, although significant as far as the proof of concept is concerned, scaling this to a functional fusion reactor is decades away. My personal belief is that the best way to achieve a workable fusion reactor would be to follow the Tokamak route, like the one presently being assembled near Toulouse in France and due ready for experimentation in 2025.

Book Review

A.C. Metaxas
Life Fellow St John's College Cambridge UK



Advances in Microwave Processing for Engineering Materials

Edited by Amit Bansal, Hitesh Vasudev
CRC Press, ebook published 30 Sept 2022, ISBN 9781003248743, pages 226.

This text discusses recent research techniques in the field of microwave processing of engineering materials by utilizing microwave radiation in the form of microwave hybrid heating (MHH). It is useful for industrial and household applications including the joining of materials, casting of bulk metal alloy material, drilling of borosilicate glass materials, development of cladding of different materials for friction, wear, and corrosion.
The book:

- Discusses the development of high-temperature resistant materials using microwave processing
- Covers the latest research development in microwave processing in the field of healthcare i.e. bio-medical implants
- Highlights concepts of microwave heating in joining, cladding, and casting of metallic materials
- Explains mechanisms of failure of materials and protection in a comprehensive manner
- Provide readers the knowledge of microwave processing of materials in major thrust areas of engineering applications

This book extensively highlights the latest advances in the field of microwave processing for engineering materials. It will serve as an ideal reference text for graduate students and academic researchers in the fields of materials science, manufacturing engineering, industrial engineering, mechanical engineering, and production engineering.
Chapter 3 of the book entitled "Microwave Drilling in sub-wavelength diameters" is written by AMPERE member Prof. Eli Jerby, who is also serving in the scientific committee of AMPERE.