Background

Conventional types of magnetic materials suffer from a number of disadvantages including limited size, its brittleness, high loss and high cost. One of the typical problems is that for application in high power conversion such as more than 20KW system, the transformer or inductor required is gets extremely difficult to obtain because of the mechanism of formation of Ferrites or powder iron and is exceptionally expensive. High frequency use of the conventional component is difficult as the permutation is too high. The Polymer–bonded magnetic material is composed of polymer matrices and magnetic powders which can be produced by traditional polymer processing methods. Hence, it offers significant advantages over the conventional counterparts. One of the important advantages is the ease of molding such as injection molding which can save on manufacturing costs and quality control.

The loss can be divided into conductor loss and core loss. The conductor (winding) loss is the resistive loss due to the current passed through the winding and they will also increase dramatically as the frequency increases because of the current distribution in the conductor at high frequency.

What are its novel and unusual features?

Our research team has successfully made use of state-of-the-art polymer-bonded magnetic materials to produce magnetic devices. In using this new method, light weight, low lost and non-brittle magnetic cores of flexible shapes and different sizes can be made. The Polymer-bonded magnetic material is composed of polymer matrices and magnetic powders which can be produced by traditional polymer processing methods. Hence, it offers significant advantages over the conventional counterparts. One of the important advantages is the ease of molding such as injection molding which can save on manufacturing costs and quality control. Also, recycling and reuse of the polymer-bonded magnetic waste materials are very easy which is very suitable for environmental protection.

What are the immediate and/or future applications of the invention?

High frequency transformers and inductors which are made of the new polymer-bonded magnetic materials can be directly used in electronic products, such as power supply. Since the power supplies is a very elementary part for all electrical equipment. The market demand is huge.

EMI is now an important requirement for all electronics, all the electronic devices must now pass through a list of EMI tests and the proposed materials can be used as an EMI screening materials for the new requirement.

Innovation

The invention is directed to a magnetic composition containing a thermoplastic resin and magnetic powders. The objective composition is produced by compounding (A) from 10 to 40 weight percent of a thermoplastic polymer taken from the group consisting of poly(methyl methacrylate) resins (PMMA), and polyethylene resins (PE), (B) from 60 to 90 weight percent of a magnetic powder taken from the group consisting of Nickel, Cobalt, NiZn Ferrite, and MnZn Ferrite, and (C) 10-20 weight percent (against magnetic powder) of Titanium Isopropoxide as a coupling agent. Furthermore, the invention is directed to a process for producing said composition, a series of magnetic cores made, produced and usage of the said composition.

Advantages

Conventional magnetic materials suffer from a number of disadvantages including limited size, brittleness, high loss and high cost. The proposed new material is flexible in size and shape and is not brittle. It is also easy to manufacture. It is especially useful for high frequency power conversion, such as over 400 kHz operations. It is boned with polymer and hence, there is an evenly distributed air-gap that is what we needed for high frequency power electronics. Many researches have found that in high frequency operation, high resistance caused by evenly distribution air-gap can reduce the eddy current loss.

27%
Reduction in manufacturing costs

30%
Saving in size

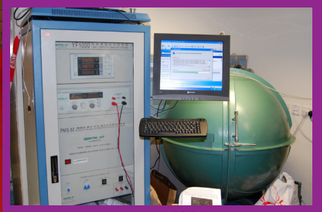
Mouldable
to virtually any shape and size

About Power Electronics Research Centre (PERC)

Electric vehicle development



Electromagnetic Interference (EMI) testing in place


Lighting measurement

The two power electronics groups in the Department of Electrical Engineering (EE) and the Department of Electronic and Information Engineering (EIE) and are well-established research groups. Both groups have an impressive research track record in the areas of power converters design and modelling, power factor correction, chaotic phenomena, motor drives, motor design, energy management, magnetics, electromagnetic compatibility and application of power electronics in power system engineering. In November 2000, the two power electronics groups merged to become the Power Electronics Research Centre. This merger offers significant advantages in staffing and equipment utilisation, as well as in the promotion of large-scale collaborative research work. The Centre has a wealth of experience in research, testing, evaluation of products and development of new technologies. In addition to conducting research and development work, the Centre provides various services to industry, such as consultancy, testing of utility system components, quality assurance evaluations and professional training. The Centre has a comprehensive range of facilities and equipment. The aims of the center are to provide high level research and development and support local and overseas industrial work. We provide technical training for local engineers who work in the field of power electronics. Regular workshops and conferences are organized by the Centre to foster the exchange of ideas among various research institutions and power electronics manufacturers.

Comparison chart - Key features and benefits

Comparison Items	Polymer-bonded magnetic	Ferrite	Result
Cost	About 0.8HKD for EI40	About 1.1HKD for EI40(3c90)	About 27% reduction
Brittle	Non-brittle	Brittle	–
Working frequency	400k~1MHZ	50kHz-400kHz	Increase to 4–10 times
Weight	42g	59g	29% reduction
Shape and size Manufacturing method	Flexible shape and size Injection molding	Limited size and shape sintering	Flexible shape and size Suitable for mass production and can save on manufacturing costs and quality control
Renewable?	Waste materials are Renewable	Waste materials cannot be easily reused	Renewable

Technical specifications

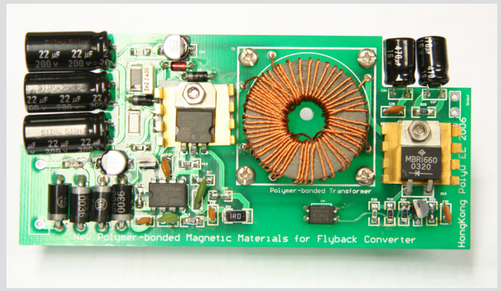
Process		5 kHz	50 kHz	100 kHz	500 kHz	1 MHz	2 MHz	10 MHz
1100 °C, 20 hours	L (μH)	43.98	42.55	42.40	42.03	41.98	42.29	55.54
	μr	33.12	32.04	31.93	31.65	31.61	31.84	41.82
1300 °C, 950 minutes	L (μH)	56.00	55.45	55.26	54.86	55.01	55.59	80.58
	μr	42.17	41.75	41.61	41.31	41.42	41.86	60.68

Magnetic Measurement Results (Tested on Ring core (Ø30×Ø15×H12mm), Loop Number N = 45)

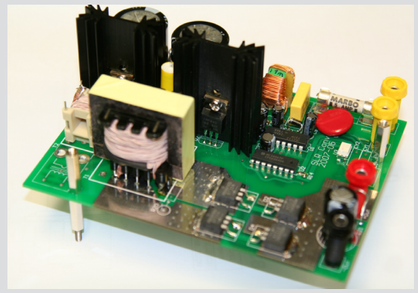
Development and Application

EI40 polymer-bonded magnetic transformer cores made of this material have been successfully used in five different types of converters, the switching frequency of the power devices in the converters are increased to 400 kHz ~1 MHz.

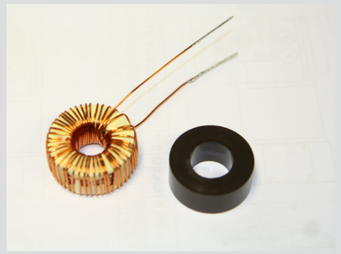
The following are two examples of power converters developed:



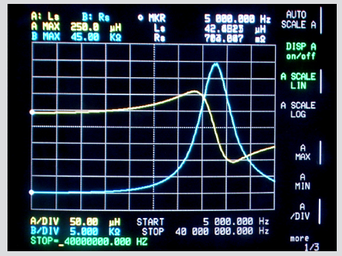
Polymer-bonded magnetic material based charger



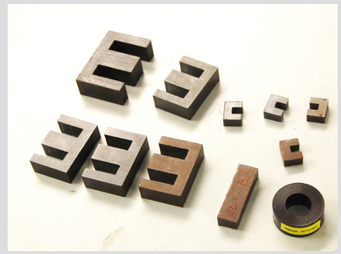
Polymer-bonded magnetic material based charger (Resonant Load Converter)



Toroidal inductor using the new material



Typical photos and Magnetic measurement results for a polymer –bonded magnetic ring cores



Polymer-bonded magnetic cores for power transformer and inductor

How long was the development process? And is it still ongoing?

The manufacturing methods for magnetic cores in our laboratory are now being transferring to industrial manufacturing method.

Patent

Two Patents have already been filed by the Hong Kong Polytechnic University.

The patents consist of the technology for the materials and processing method. The circuit and application for the special materials has also been described.

The details of the filed patent can be reached through: www.uspto.gov

Contact person – Professor Eric Cheng

Prof. Eric Cheng is a professor in the Dept. of Electrical Engineering of the Hong Kong Polytechnic University. He is the group leader of Utilization of the Department and Director of Power Electronics Research Center of the University.

His research interests cover all aspects of power electronics, magnetics, machines, EMI and drives. He has published over 200 papers and 7 books. Since he joined the Department in 1997, he has been working on 31 research and development projects as a Principal Investigator with total funding of more than $35 Million. He also has been Principal Investigator for 4 CERG projects.

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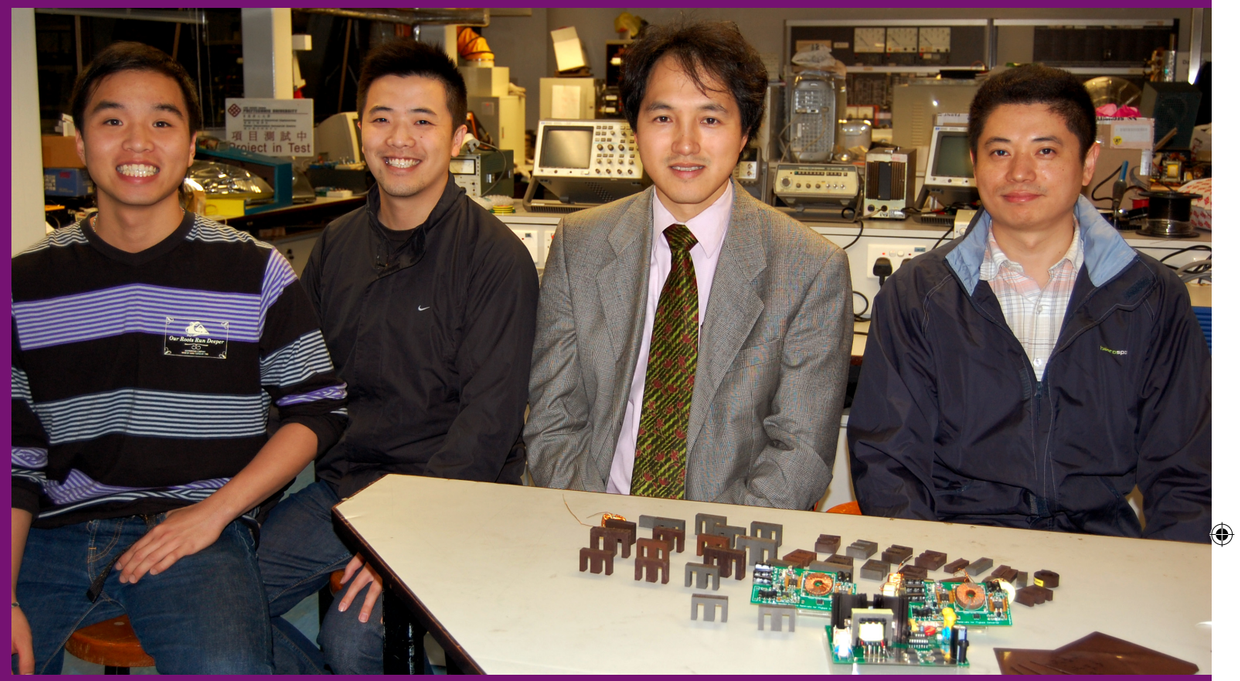
THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

POWER ELECTRONICS RESEARCH CENTRE

Invention of Polymer-Bonded Magnetic

Materials for Power Conversion and EMI Screening



Research Team Members delightfully presenting their Polymer-Bonded Magnetic Materials at the PERC Centre. (from left) Mr. C.K.Cheong, Mr. T.K.Cheung, Prof. Eric Cheng, and Dr. Kai Ding

Latest News

Researchers at the The Hong Kong Polytechnic University have invented a new type of Polymer bonded magnets with magnetic properties. They can be used as the power transformer, ferrites screen, and power inductor in addition to many other types of application. It is so promising that the new material has been found to produce outstanding results for power conversion and screening.

Other important current development for the centre includes:

- Integration of wheel and motor development for electric vehicle – provide real 4-wheel drives and improve dynamic response.
- High power battery charger for all applications – Applications for power drill, communication devices and electric vehicle and renewable energy storage.
- LED lighting for indoor, outdoor and vehicle lighting – Development of the optical, thermal management, power conditioning techniques, dimming and spectral control using power electronics techniques.
- Solar power tracking for renewable energy source – Development of the position and electric power tracking for solar panel and the associated power conditioning.

The Research Team proudly holding the Brussels Eureka 2007 Gold Medal with Mention Award and their Invention Devices. (from left) Mr. T.K.Cheung, Dr. Y.W.Wong, Prof. Eric Cheng, Mr. Bonus Ho, and Dr. Kai Ding

Eureka 2007 Gold Medal with Mention

16th China Invention Silver Medal 2006