Introduction

Engagement: On 29 August, 2012, I was retained as a consultant to assist ZENN Motor Company Inc. ("ZENN") in reviewing the technological developments at EEStor,Inc. of Cedar Park, Texas. ("EEStor") and to provide a technical interpretation of EEStor's products, manufacturing process, and technology. I understand that ZENN is both a shareholder of EEStor and has a technology agreement with EEStor that provides it certain rights to utilize the technology. I understand EEStor has been developing a capacitor technology which they expect will have Energy Storage Capability well in excess of today's capacitors, and meeting or exceeding the Energy Density of current capacitors or batteries.

Independence: I do not own any shares in ZENN and I confirm I have no arrangements or understandings with ZENN other than this consulting engagement. I am fully independent of ZENN for the purposes of providing the consulting services described herein.

Qualifications

I have been employed in the capacitor industry for over 40 years, and have more than 50 patents in the field. I retired in the spring of 2010 from AVX Corporation, a leading manufacturer of capacitors, as a Fellow in the Firm, the third of only five such positions at AVX since its founding in the 1930's.

Review of Visits to EEStor

September 10 visit to EEStor: On September 10, 2012 I visited the EEStor facility in Cedar Park, Texas with representatives of ZENN. We met with Richard Weir, CEO of EEStor and Tom Weir, Vice President. We were given a tour of their manufacturing facility which has more than sufficient area for EEStor's pre-production line, which line has been fully equipped with first level automation as well as necessary testing and metrology equipment. None of the manufacturing equipment was running and at no time did I observe the manufacturing process or see any layers ("EESUs") actually being manufactured. We met 3 of the employees who were doing electrical testing, Inductively Coupled Plasma (ICP) analysis, and non-production activities.

What I saw in their facility (of approximately 2500 square feet) were various process equipment; described as the CMBT (Composition Modified Barium Titanate) reactor, the CMBT/polymer mixer, the dielectric applicator, and a small deposition system. Each of these process equipment systems were similar to equipment common in the art, that I had worked with over the years, and knew to be appropriate to that process, and in my opinion, easily scalable to higher volumes. The facility and its equipment could not be classified as "lab equipment", but rather as a pilot production line, where each system had larger counterparts readily available for when there is need to scale the production process.

During the visit of September 10th, we tested a (6mm x 6mm x 25 micron thick) sample of EEStor's early (February 2012) product on a specialized instrument described as an "integrator". While not familiar with the specific equipment, the operation of it was consistent with testing instruments I knew. It is designed to integrate the current versus time at various voltage levels, and was thus able to determine the charge going into, and being stored by, the test piece at each voltage. The measurement showed energy stored by the tested sample as 200 micro joules at a voltage of 1250 volts. This calculates out to be approximately 0.24 wh/liter and implies a permittivity of about 1000. While I was not able to calibrate the testing instrument on my own, the tested sample demonstrated energy storage at increasing voltage without diminishment of capacitance.

My conclusion from this test was that the results represented a breakthrough in capacitance/voltage stability. Unlike capacitors I was familiar with; this device did not break down, or diminish in efficiency with high fields, up to 50 volts/micron. The leakage current at the 1250 volts level was displayed as 1 microamp, but since that was the last digit on the display, a lesser value could not be resolved. In my view, this is very good leakage current for 1250 volts. It is comparable to high voltage ceramic whose permittivity is similar, but the commercial comparable part (e.g. Panasonic HV disk) has a dielectric thickness of about 2500 microns versus this EEStor sample whose dielectric was 25 microns thick.

In follow-up discussion with Mr. Weir he described the history and progression of the EEStor process, which will be detailed later, but in simple terms his process consists of mixing his CMBT in different configurations and chemistry with a proprietary polymer and applying it between metal electrodes to form the basic capacitor.

The two main constituents here are worthy of further detail. The CMBT he has developed has a permittivity (dielectric constant: the higher, the better) of over 22,500 across a temperature range of -20 to +65°C. These parameters were verified by an independent scientist, Dr Edward Golla, on May 20th 2009. EEStor advised me that since that time they have significantly improved the powders, but I was not able to test or verify this. By comparison, the industry standard BT (Barium Titanate) material only has a permittivity of approximately 3500, for an "X7R" dielectric. (mid-K with similar cap/temp behavior) The polymer used by EEStor was formulated to have a very high permittivity so when mixed, permittivity could still remain relatively high. Attempts by others to develop similar products have failed in this regard. For example, Georgia Tech and Penn State have not been able to achieve a permittivity over 50 in their mixture of CMBT in polymers. In fact, there are commercially available CMBT/Polymer products being sold today whose permittivity is 30 or less. EEStor tested polymers in my presence that exceeded permittivity of 100,000.

Mr. Weir also discussed the purpose of making the blend, which is not obvious to the casual observer: In classic ceramic capacitors with high voltage charge, any physical penetration into the device, as may happen in an accident, would cause the brittle material to fracture, and then short, creating a dangerous release of energy. EEStor's ability to manufacture a flexible material, so that the internal layers will not fracture, mitigates the likelihood of dangerous energy release in a destructive accident. Of course this theory will require extensive testing to prove.

We were then presented with some sample results to date. EEStor had prepared samples of low-percentage CMBT in polymer. The values are given below, with the calculated permittivity in the right most column.

Sample #	Capacitance	DF	Thickness	Permittivity
	uF	%	microns	
1	2.3	134	55	411,462
2	1.4	105	53	211,512
3	9.4	235	62	1,620,439
4	2.2	130	56	387,826
5	4.6	198	57	820,937
6	2.6	146	54	428,570
Average				**646,791**
% Dev				**59%**

Table 1: Parameters of the first witnessed samples at EEStor

The first thing that struck me was the very high permittivity, not witnessed by me before in my career. The down-side of these results is that the DF (Dissipation Factor) was high; it really should be below 10% to be comparable to other technologies, and the large variation (59%) of the calculated permittivity is not acceptable. I was not able to verify or independently confirm these numbers.

Mr. Weir outlined EEStor's development plans for near term. The objective was to lower the DF, reduce variability, and increase permittivity in the EEStor samples. He proposed to make a cell with even lower CMBT concentration than the samples described above, repeat the cell described above, and then make a cell with even higher concentration of CMBT, to see where the "sweet spot" concentration of CMBT might fall.

We discussed various other topics having to do with the scalability and testing issues. Mr. Weir advised that the integrator had not been calibrated thoroughly, so the energy density values measured may be inaccurate.

Subsequent to my visit Mr. Weir advised that EEStor had succeeded in testing the voltage behavior of a new sample which had a permittivity of 11,300 that was constant up to 750 volts. I was not able to verify or independently confirm these results, but note that this would be a significantly positive development if verified. It would confirm that EEStor has been able to make breakthroughs in terms of high permittivity and the maintenance of such permittivity across a range of voltages. Of course both DF and leakage would need to be observed.

<u>October 12 visit to EEStor:</u> On October 12, 2012 I again visited the EEStor facility with a representative of ZENN. We met with Mr. Weir. Mr. Weir advised that the integrator which is the key piece of testing equipment was under repair to correct issues with it so I would not be able to observe tests over a range

of voltages (Mr. Weir previously notified me of the needed repairs). I understand these tests will be conducted shortly.

EEStor changed the matrix material slightly, and manufactured samples with its targeted product level of CMBT concentrations. I observed and verified the results which are reproduced in the table 2 below:

Very Low Concentration of CMBT				
Sample #	Cap	DF	t, um	K
	uF	0%	microns	(rounded)
1	34	380	71	6,800,000
2	49	430	73	9,700,000
3	39	390	71	7,800,000
4	23	311	72	4,600,000
Average	**36**	**378**	**72**	**7,225,000**
% Dev				**21%**

Targeted Product Level Concentration of CMBT				
Sample #	Cap	DF	t, um	K
	uF	0%	microns	(rounded)
1	27	144	62	4,700,000
2	35	167	65	6,100,000
3	12	90	66	2,100,000
4	20	121	65	3,500,000
Average	**24**	**131**	**65**	**4,100,000**
% Dev				**32%**

Table 2: Parameters of the documented CMBT variations

The important aspect to note is the dramatically higher permittivity, now well into the millions. In my experience, I have never seen or read of values this high in any materials. Also, note that, despite the much higher permittivity than seen in Table 1, the variation has been reduced in the samples tested in Table 2.

In discussions it was agreed that the material does not yet have all the key properties needed for commercial viability. The DF has to be reduced, and the leakage current, expected to be high, has to be characterized and reduced. As mentioned above, the material could not be tested for the key energy density factor, as the integrator was being repaired and due to the DF being excessively high are not ready for energy level testing.

In order to verify the accuracy of the readings of the capacitance instrument we used to test the product, Mr. Weir demonstrated the readings on a “standard” capacitor. These are special capacitors that are calibrated by a National Bureau of Standards lab, to certify that the values are accurate. To double check his calibration, I had brought with me capacitors whose parameters I knew. We had a multilayer ceramic, and a double-layer capacitor, which we tested, and the test instrument returned values which I know to be accurate. I was therefore comfortable that the high permittivity readings I observed were accurate.

It is important to note that the sample that was tested was a 6mm square device, (quarter inch) about 65 microns thick. (Roughly one-fourth the length and width of a postage stamp and about the same thickness). This had comparable capacitance to a Multi Layer Ceramic Capacitor (MLCC) or double layer capacitor at less than one hundredth the volume. It should be pointed out that the current EEStor device does not have commercial viability without some of the other parameters verified, but the capacitance per unit volume is striking.

We then had a discussion relating the performance of the present EEStor product to other existing capacitor technologies. We discussed what markets might be accessible if EEStor should decide to enter them to provide cash flow for growth. Even without confirming significant Energy Density it may be possible for the existing products of EEStor to access current capacitor markets, which could potentially provide a source of business prior to developing energy storage products with full capabilities for ZENN. Possible markets include:

> **Level 1:** *The CMBT powder, would potentially sell to current Multi Layer Capacitor (MLC) manufactures and it would appear there is a significant financial margin available to EEStor.*
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> **Level 2**: *Embedded capacitors are close to what EEStor is already making. They consist of a 25-100 micron dielectric, coated on both sides with a conductor. They are intended to be molded into a circuit board. The typical capacitance of such a layer is about 10 nF per square inch. ESStor's recently demonstrated layer currently shows over 1000 times the capacitance/unit area of other commercially available embedded capacitor layers.*
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> **Level 3:** *Single Layer Capacitors, (SLC). This is a high ASP (Average Selling Price) product, where EEStor has two key advantages: One is the higher, voltage stable K and the other is the physical flexibility. These parts are usually mounted by soldering on one side, and wire bonding on the top. The problem with ceramic is that it is brittle, and sometimes not perfectly flat, so they may break. EEStor's won't break.*
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> **Level 4:** *MLC, aluminum or tantalum electrolytic and double layer capacitors. This is more complex as EEStor would have to have a multilayer stacking process to compete.*

Observations and Summary

As was mentioned in my initial report to ZENN after my first visit to EEStor, I believe that EEStor has made significant technological progress towards developing its EESU. The extremely high level of permittivity achieved is impressive. While on my first visit I was able to verify a layer with permittivity of 1000 maintain permittivity up to 1250v. The subsequent testing of a layer of 11,300 permittivity maintaining its permittivity up to 750v would be impressive if it can be verified. More importantly, EEStor has successfully demonstrated to me newer layers with permittivity far in excess of any the layers previously produced (permittivity into the millions). If the composition of such layers can be modified so that dissipation and leakage current are reduced and resistivity is increased, there is the potential for very high level permittivity layers which can maintain such permittivity over a range of voltages. If this is achieved EEStor would have made a breakthrough in Energy Density and therefore energy storage. However, this critical next step still needs to be achieved and demonstrated.

My visits to EEStor suggest that EEStor has managed to refute the two main capacitor industry assumptions, namely:

1. "Higher permittivity means more losses"; and
2. "The mixture of any polymer with any dielectric will result in permittivity less than 100".

It appears that EEStor is now successfully disproving long standing assumptions.

Based on my visits to EEStor I believe some of the key accomplishments in its process include:

1. Very stable aqueous constituents

Aqueous chemistry preparation is not new, it is used on special materials, where cost and time are not critical, and timely additions of reactants can be made carefully, precisely, and with both temperature and turbulence control. As the final compounds are added, the ceramic powder precipitates from the solution. The shelf life of the component materials may be limited, so storage can be a problem.

EEStor has developed a chemistry that allows the primary solution to be very stable. In fact they have shown it can be stored for five years without degrading. When needed, the primary solution is put into the reaction vessel, the liquid dopants are added, the chemistry is verified by analysis using ICP, and then a single ingredient precipitates the virtually perfect crystalline structure of the CMBT, at the desired average particle size (particle size was not verified in my visits).

2. Precise computer controlled mixing system that can handle multiple components at a time

The whole process is computer controlled, and monitored. Multiple ingredients can be dispensed precisely with mass flow controllers, into the mixing system.

3. Control of the precipitation timing to control particle size, structure, and chemistry

4. A means to thoroughly clean the freshly precipitated powder

Once the powder is precipitated, it is rinsed to remove the by-products, most of which are water soluble. That step itself required considerable development and is a breakthrough.

5. High temperature treatment without sintering that would require harsh grinding

The powder is subjected to a high temperature treatment to complete the diffusion, and remove organics. Thanks to another insight, the temperature is not high enough to cause sintering into hard agglomerates, and the soft clumping is broken up in the subsequent high-shear mixing with the polymer precursors.

Another process invention was being able to activate the surface of the CMBT and mixing it with the polymer in such a way as to eliminate voids, and provide uniform, intimate contact with all the ingredients.

The next breakthrough was to be able to efficiently lay down a uniform coat of that material, and then to cure it without gaseous evolution that could create harmful voids.

In my opinion, based on 40 years of industry experience, the pilot line process that EEStor has developed for the preparation of the CMBT and its dispersion into a polymer is scalable and has the potential to produce a product with very high purity and consistency of structure. That will translate to high yield and continued reduction in cost.

It is important to note that neither ZENN nor I have been provided with layers to test independently at facilities outside of EEStor's. As mentioned above I have not observed the EEStor facilities in operation and it is my understanding that ZENN has also not seen the facilities in operation. In order to comment on the commercial viability of EEStor manufacturing process, actual observation of the facility in operation would be needed. My observations above relating to the process and the manufacturing capabilities are based on my discussions with EEStor, my observations of their facilities and my experience. It should be noted that EEStor has advised me it does not feel it is necessary for me to observe its production process in action and that it considers this proprietary. However, it is my understanding that when and if EEStor achieves targeted levels of Energy Density it intends to provide layers to ZENN to test independently. To date ZENN has not been provided with layers to test.

"John Galvagni"

October 23, 2012

Information contained in this report relating to EEStor, Inc. or the energy storage technology being developed by EEStor has not been reviewed by EEStor and EEStor does not assume any responsibility for the accuracy or completeness of such information.