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Research Article

Experimental Observations on the Lattice Energy Converter

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Abstract

The Lattice Energy Converter (LEC) is a relatively simple gas-metal device that is able to directly generate an electric voltage and current by an unexplained mechanism, possibly related to LENR. Due to its simplicity and high reproducibility, the LEC is a very interesting experiment that may provide insights into LENR phenomena, as well as potentially being a practical new solid-state energy source. This paper describes a successful replication of a Lattice Energy Converter (LEC) and a number of experiments and observations made to investigate the nature of the effect and its electrical characteristics, and to exclude the presence of artefacts and conventional explanations. Compared to a control device, the active LEC was able to generate a stable voltage in excess of 300 mV and a current up to a few microamperes. These results are consistent with previous data published by the inventors and other replicators, so the good reproducibility of the device is confirmed. The primary and most interesting effect happening inside the device is the apparent ionization of the gas between the electrodes, allowing a significant current to flow through an otherwise insulating gap. The spontaneous voltage is instead a secondary effect, due to the presence of a bimetallic pair in contact with an ionized conductive medium, forming a kind of gas-phase battery.
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1. Introduction

In March 2021 the author started a replication of Frank Gordon's and Harper Whitehouse's Lattice Energy Converter (LEC), as described in [1], [2] and [3]. The most interesting feature of this device was its simplicity and apparently its high reproducibility. The device was in fact already replicated by other researchers. In designing the replication experiments the first concern was to exclude any conventional effect possibly due to electromagnetic interference, noise, instrumentation drift and other common (but not obvious) effects. To this end, a series of control experiments were designed and performed before the actual replication. The second aim was to design a very simple structure that can be easily modified and reutilized in a variety of tests.

Once the device was built, the control experiments were performed, confirming the absence of conventional effects, and a satisfactory instrumentation sensitivity and noise level. Then the active electrode was made, and the actual replication was tested. Compared to other previously described implementations, the devices here reported employed

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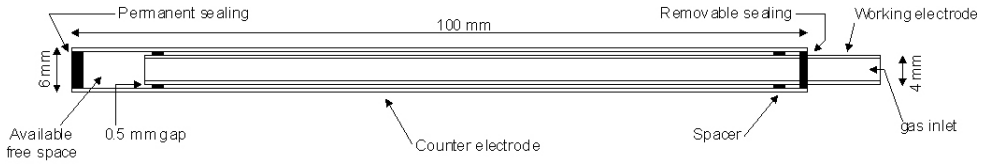

Figure 1. Design of the test LEC device.

a Fe co-deposition instead of a Pd-based one. This made the process very simple (due to the common availability of Fe and Fe-based salts, compared to Pd) and inexpensive. The results obtained were almost identical to the ones reported by Frank Gordon and Harper Whitehouse, confirming the high reproducibility of this experiment and the reality of the underlying effect. The most interesting feature of the device is not only its ability to generate electrical power, but the fact that the internal gas appears to be ionized by an unknown agent.

2. Structure of the Device

To replicate the LEC, a "laboratory" version of the device was designed, i.e., a very simple structure which can easily be modified, without the need to entirely rebuild the device for each kind of test. This structure is depicted in Fig. 1. Both electrodes are made from small diameter metal tubes (the outer tube is 6 mm OD, and the inner tube is 4 mm OD, both 0.5 mm thick). The working electrode (WE) can be electroplated, inserted in the counter electrode (CE) with a couple of rubber spacers. Then the assembly can be sealed with rubber fittings or epoxy glue. Given the device dimensions, the gap between the two electrodes is 0.5 mm. The WE tube is also used to evacuate and fill the device with the chosen gas (the 4 mm tube can be directly fitted into off-the-shelf pneumatic fittings). Different metal combinations were tested, among which: brass, copper and aluminium, as well as different gas pressures, in order to verify how the generated voltage and current were affected.

The first step was characterizing the control devices, i.e., devices with identical materials and mechanical structures as the active device, but without the co-deposition layer on the WE. This provided a clear picture of the baseline behaviour. These tests gave, among other things, a clear answer to the hypothesis of simple galvanic voltage generation or the existence of other conventional phenomena.

3. Experiments on the Control Devices

Three control devices were tested, made with a brass WE and three different metals as the CEs: brass, aluminium and copper (see Fig. 2). The first tests were performed with air at atmospheric pressure, 23.9 °C, 46% relative humidity (RH). Tests were repeated with hydrogen, then repeated again at lower pressure for both gases.

A Keithley (Tektronix) DMM6500 multimeter was used, featuring a very high precision, customizable integration time and filtering. The instrument was set to 10 MΩ input impedance and an integration time of 20 ms (the period of the local 50 Hz mains) plus averaging of 100 samples.

The capacitance of the three devices was measured, since this may affect their dynamic behaviour and it was directly related to the device geometry, so it was useful for comparing them. Results were the following:

Brass-Brass: 30 pF ± 10 pF
Brass-Aluminium: 30 pF ± 10 pF
Brass-Copper: 30 pF ± 10 pF

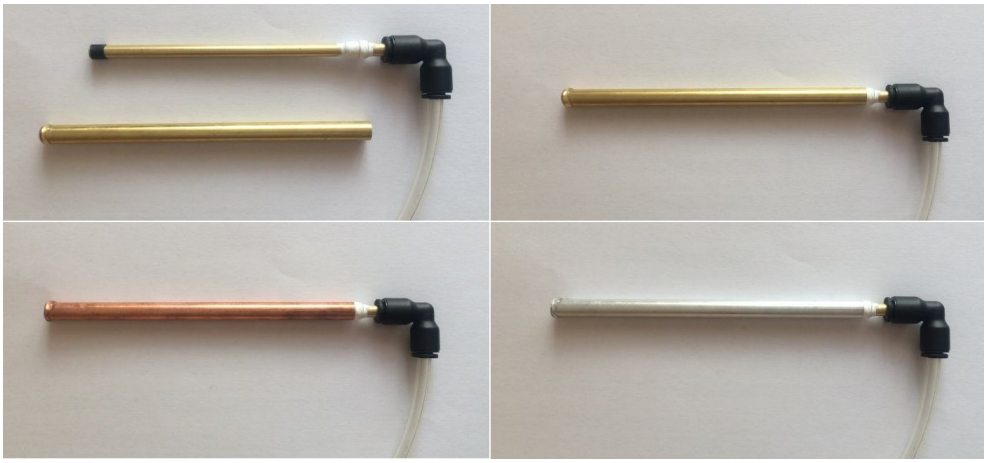

Figure 2. Some LEC devices used for the control experiments: the inner tube (WE) is the same, the outer tube (CE) can be changed in order to test different metal pairs.

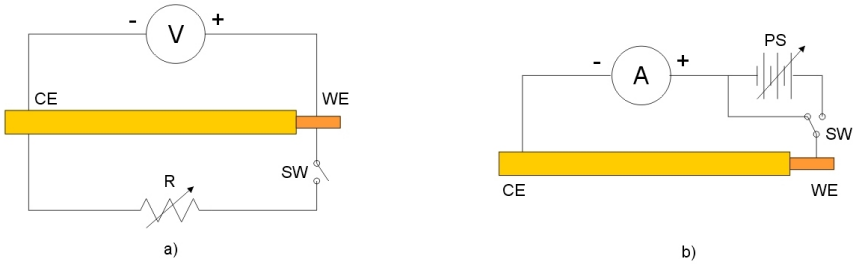

Figure 3. a) Voltage measurement: the SW switch controls the open-circuit or loaded operations through the variable resistor R. b) Current measurement: the SW switch controls the spontaneous (as in figure) or forced current mode, putting in series the variable power supply PS.

So, the geometry was consistent for the three devices, and the capacitance was in good agreement with calculations. The difference in metals was not relevant.

The second measurements were on open circuit voltage (Fig. 3a). The voltmeter was connected to the devices (WE to the positive probe, CE to the negative one), obtaining almost the same result for the three devices. The readings were the following:

- **Brass-Brass:** 0.01 mV $\pm$ 5 μV
- **Brass-Aluminium:** 0.01 mV $\pm$ 5 μV
- **Brass-Copper:** 0.01 mV $\pm$ 5 μV

This result clearly implies that the devices do not generate any spontaneous voltage, even when different metals are used together. This was a first confirmation that the voltage observed in the LEC by the inventors is not due to bimetallic, galvanic, chemical effects, or other conventional phenomena. The above-described voltages can also be considered the noise floor of the instrumentation and setup for the voltage measurement.

The third measurement was done to test the capability of the device to conduct a current when an external voltage was applied (Fig. 3b). A DC voltage ranging from -60 V to $+60$ V in steps of 5 V was connected to the device, measuring the flowing current. The following results were obtained, actually independently from the applied voltage:

- **Brass-Brass:** 0 μA $\pm$ 0.5 nA [from -60 V to $+60$ V]
- **Brass-Aluminium:** 0 μA $\pm$ 0.5 nA [from -60 V to $+60$ V]
- **Brass-Copper:** 0 μA $\pm$ 0.5 nA [from -60 V to $+60$ V]

This data essentially imply that the devices do not conduct current. This result is actually a second confirmation that the original LEC has quite different behaviour: according to the inventors, it not only generates a voltage, but it is also able to conduct a current (either spontaneous, or under an external stimulus). By increasing the amount of filtering and averaging on the instrument, it was possible to determine with good precision the residual current during this experiment; it was on the order of 100 pA.

All these measurements were repeated at a lower gas pressure (down to about 300 Torr), just to verify also the influence of this parameter. The results were essentially the same. The conclusion was that a gas pressure in this range do not significantly affect spontaneous voltage and currents. All the above-described tests on the control devices were repeated using hydrogen instead of air, obtaining the same results.

These results were very robust and lead to the conclusion that a device with the structure of the LEC, with an untreated WE electrode, does not generate a spontaneous voltage and is not capable of conducting a significant current. This behaviour is not affected by the employed metals, by the type of gas (air and hydrogen tested), and gas pressure (tested range from 300 to 760 Torr). The behaviour of the control device is exactly the one expected from the theory of electricity conduction through gases [4].

The performed measurements allowed me to assess the instrumentation sensitivity and noise level, that allow detection with high confidence voltages in the order of tens of μV and currents below of nA, that are at least 3 orders of magnitude smaller than the one expected from an active LEC.

4. Tests on the Active LEC

The device used for the active tests was exactly the same described previously as control. The only difference was the co-deposition process, involving the plating of a thin layer of Fe on the brass WE tube.

4.1. Co-deposition Process

The working electrode (WE) was gently rubbed with fine sandpaper and cleaned with alcohol, then it was placed in the electrolytic cell.

The cell was constructed with a test tube, with four 1 mm iron wires surrounding the WE. The wires were connected to the positive voltage while the WE was connected to negative (ground). The electrolyte was 1/4 HCl at 20% concentration, 3/4 tap water (so essentially about 5% HCl). No $FeCl_2$ was added since the Fe++ ions were directly obtained from the anode wires during the electrolytic process. The current was set by finely regulating the power supply voltage. The cell is shown in Fig. 4.

The current was set and maintained as follows, according to Frank Gordon's recommendations:

8:00 - 8:35:	0.7 mA	(80 μA/cm^2, 0.167 V)
8:35 - 9:05:	1.7 mA	(190 μA/cm^2, 0.254 V)
9:05 - 12:00:	16 mA	(1.8 mA/cm^2, 0.375 V)
12:00 - 16:00:	25 mA	(2.8 mA/cm^2, 0.450 V)

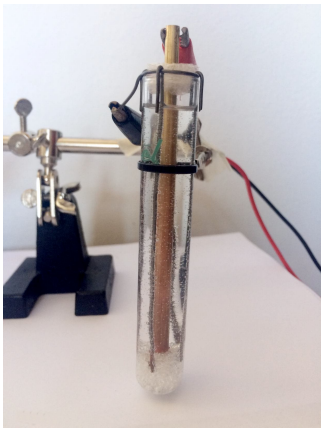

Figure 4. Electrolytic cell used for the co-deposition at the beginning of the process. This picture and the following one were taken during the first experiment. Note that the colours of the wires do not indicate the applied polarity.

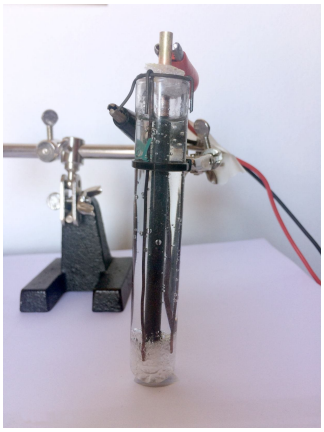

Figure 5. Appearance of the WE at the end of the co-reposition process.

Temperature was 26.4 °C, 45% RH at the beginning of the process, 26.6 °C, 51% RH at the end. At 15:30 the electrode appeared as shown in Fig. 5: it became black quite abruptly.

It can be noted that, even if this protocol proved to be effective, subsequent experiments suggested that this co-deposition method is very sensitive to a number of factors (e.g. cell dimensions, applied voltage, HCl concentration, etc), so more repeatable results can be obtained starting from a conventional solution of 0.1 M of $FeCl_2$.

4.2. Preliminary Test

The plating process was ended at 16:00, the power supply disconnected and the WE extracted, rinsed with tap water and dried with a soft paper towel. The plating appeared quite uniform, well attached to the brass substrate and with a very fine porosity. The thickness was not measurable (estimated on the order of 10 μm). An unexpected phenomenon

Figure 6. Open circuit voltage measured on the brass - brass device after about 1 hour from the co-deposition and device assembly.

was noticed while taking out the WE from the cell: the WE, as well as the iron wires, became magnetised, attracting each other. This effect may be due to the formation of magnetite nano-crystals, which also would account for the black appearance of the deposited layer.

The WE was then inserted into the brass counter electrode (CE) in air at atmospheric pressure. No hydrogen was added at this stage. The voltage was at first checked with a handheld multimeter with 10 MΩ input impedance.

The initial reading was close to 0 mV, then in tens of seconds, it started increasing and stabilizing around 242 mV. This was a clear indication that the device was generating a voltage. The device was closed but not permanently sealed, in order to allow further experiments. The following experiments were done as fast as possible, in order to prevent the oxidation of the thin Fe plating layer and/or potential hydrogen desorption.

4.3. Voltage Measurements

The first test was to accurately measure the open circuit voltage and short circuit current of the device (Fig. 3a and 3b), using the brass CE as well as the aluminium and copper ones. The positive probe of the DMM6500 multimeter was connected to the WE, the negative to the CE. The reported signs of voltages and currents reflects this choice. The voltage measured on the device with the brass CE was $\mathbf{-307\ mV}$, the short circuit current was $\mathbf{-2.4\ \mu A}$. The voltage of the aluminium CE was **223 mV**, and the current $\mathbf{1.5\ \mu A}$. The voltage of the copper CE was $\mathbf{-234\ mV}$ with a $\mathbf{-0.69\ \mu A}$ short circuit current. The voltage of the brass CE increased slowly over time, so probably also with the other two metals higher value would be obtained by extending the measurement time. During this experiment the peak voltage with brass CE was about 330 mV, as shown in Fig. 6.

All subsequent tests were done with the brass CE only.

Another test was done by loading the device with various resistors (Fig. 3a). The result is shown in Fig. 7. The behaviour is exactly the one reported in [1], showing an internal resistance in the order of 120 KΩ.

4.4. Current Measurements

The capability of the active device of conducting a current was tested as previously done with the control devices, by applying an external voltage. The result is shown in the Fig. 8. The device was apparently able to conduct a significant amount of current, so the external voltage range was limited to ±10 V, in order to avoid damaging the device (e.g., by desorbing the hydrogen or damaging the co-deposited layer). Maximum current at 10 V was about 136-140 μA. Compared to about 100 pA measured on the control device, the active device showed a 6 order of magnitude increase in

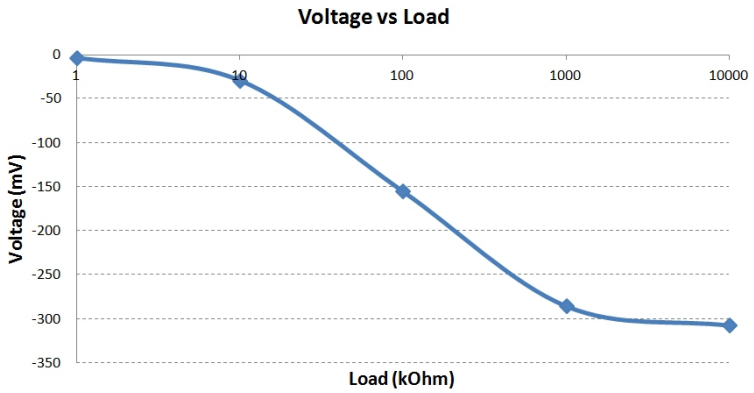

Figure 7. Voltage generated by the brass-brass LEC when a variable resistive load was applied.

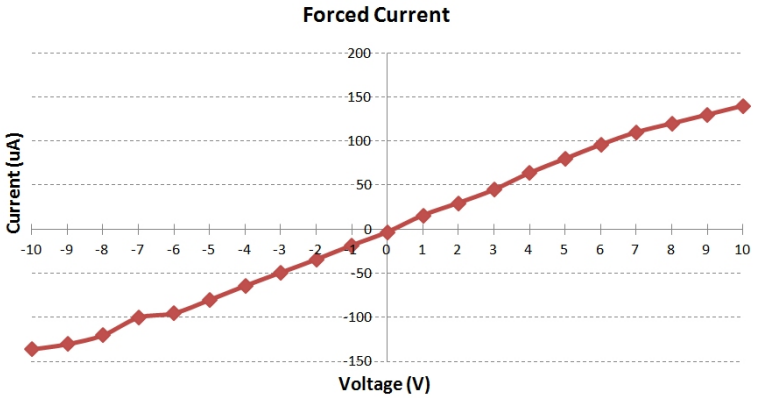

Figure 8. Current through the device by applying an external voltage ranging from −10 V to +10 V.

conductivity. It can be noted from the plot that the current tends to saturate at higher voltages: this is important because it is indicative of a true gas conduction phenomenon with limited charge carriers and not other type of conduction (e.g., through Ohmic material).

4.5. Additional Experiments

In order to verify the capability of the device to generate useful power/energy, the LEC was connected to a 100 μF electrolytic capacitor, and the charging process was monitored. The result is shown in Fig. 9. The capacitor was fully charged in about 90 seconds. It was then disconnected and the charge was measured. The stored voltage was 309 mV, so the stored energy was 4.7 μJ. The time constant of the charging curve was 15 s. Since the time constant is equal to

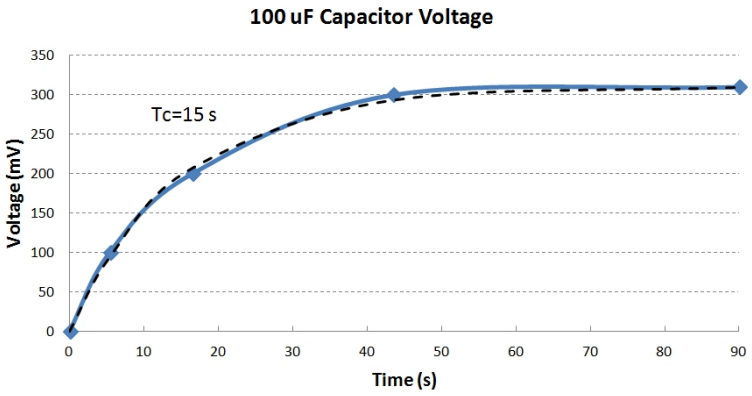

Figure 9. Results for the capacitor charging experiment.

the RC product of the circuit, the internal R of the LEC can be evaluated as about 150 kΩ. This is in good agreement with the load plot.

Another test was done on the naked WE (in air), with a Geiger-Muller counter (LND712 tube, mica window, alpha sensitive), in order to detect potential radiation. The counts for background, for the sample and for the sample plus a plastic shield, during an integration period of 10 minutes were: 9.4 CPM, 11.4 CPM and 11.6 CPM respectively. So, no significant evidence of radiation was found.

Lastly, the naked CE was left in air and in darkness for about 1 hour, in contact with a glow-in-the-dark plastic strip containing ZnS(Ag) and some fluorescent substances to test for low energy photons in the range of far UV. No fluorescence or phosphorescence visible to the naked eye was excited in the materials.

4.6. Final Considerations

All of the tests were limited by the short time available before signs of oxidation (rusting) appeared on the iron WE co-deposited layer. This effect can be reduced when the WE is sealed with hydrogen inside the CE. The day after the experiment, the condition of the WE was as shown in Fig. 10, where visible oxidation can be noted. In this condition the LEC performance decreases (the measured voltage was 50 mV or less). It is not clear if this effect was due to oxidation, hydrogen desorption or both.

All the experiments were repeated a number of times, by employing air, hydrogen or a mixture of the two. In all cases the results were very similar.

5. Conclusions

A working LEC device was successfully replicated. The entire process was not difficult or critical in any way. The capability of the LEC to conduct a current can only be explained by the emission or generation of ions by the active WE. The kind of emission of the WE and its properties remains unknown and requires further investigation. The capability of the device to conduct a current in both directions implies that the same amount of charge of both signs are present in the gas. These are most probably generated in the gas itself by an unknown source of radiation. In order to ionise the gas this radiation must have an energy at least on the order of some tens to some hundreds of electron volts. The generated

Figure 10. Oxidation appearing on the WE after exposure to air (oxidation is mainly on the left side).

voltage varied with the employed metal pairs, and changed its sign when aluminium was used. This is in accordance with electrode potentials (considering iron for the WE). This may imply that the voltage generation can be explained by some relatively conventional process (even if the environment and conditions are not conventional). A very similar effect has previously been described in a similar configuration, but with the gas ionized by an external radioactive source [5]. The ionization in the LEC cannot be explained with conventional (electro)chemical processes, requiring an energy that is generally beyond the chemical range. So, the ability to ionise the gas is the most surprising and interesting characteristic of the LEC and suggestive of the possible involvement of LENR phenomena. With reference to this, the observed phenomena are in good accordance with the ones described by Rout and Srinivasan on deuterated palladium samples [6].

Further studies are needed to understand the root phenomena observed in the device, in particular the mechanisms and the agent of the gas ionization. However, it is interesting to note that the device, even without a satisfactory explanation, can be prospectively and quite easily scaled-up and used as a practical energy source for some low power applications.

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