CELTIG

A MESSAGE FROM THE CEO

Since the discovery of graphene in 2004, a whirlwind of research has developed worldwide in a truly global effort to capitalize on the amazing physical properties of this 2-dimensional crystalline material formed purely by carbon atoms arranged on a hexagonal grid. Graphene possesses astounding mechanical properties such as tensile strength and elastic modulus, incredible electrical conductivity and ampacity, and a very high thermal conductivity, all coupled into a material which is flexible, chemically and thermally stable, and also environmentally benign. It is no wonder, therefore, that this new material has attracted such a high degree of excitement and research investment. Billions of dollars have been invested in research and development infrastructure and academic programs, all aimed at capitalizing on the predicted potential for graphene to revolutionize the way the world operates. Much speculation has appeared predicting the growth of the burgeoning graphene industry over the next decade to be on a similar scale to that of the plastics industry in the 1960s and 1970s. The only problem, however, is that graphene has proven notoriously hard to make.

Endless conjectures have appeared, usually backed with very little in the way of bona fide science, of new and ingenious applications of graphene, ranging from room-temperature semiconductors to conductive paints and graphene fibers. All of these applications, of course, rely on an industry that can readily produce large quantities of high quality and inexpensive graphene. Current analysist projections of the graphene industry generally start at about $10,000,000,000/year by 2030 at the low end of the range. These wild speculations rely not only on the production of large quantities of graphene, but also on rapid adoption of graphene in actual industrial applications, of which there currently are none. There are no current industrial-scale applications of graphene for the same reason as mentioned above: graphene has proven notoriously hard to make. In today's market, a few kilograms per day of high quality graphene is the extent of global production. Sure, there are many companies out there selling a low grade of graphene, which is basically nothing more than thin graphitic particles or a reduced graphene oxide; however, the number of reputable companies selling high quality graphene products is still rather low, and the total amount of material that these manufacturers can produce is nowhere near the level necessary for wide-scale industrial adoption of graphene.

Most of the worldwide production of graphene today is used for academic, benchtop research on potential technological applications. Very little effort is being devoted by industries to graphene research and development, simply because high quality graphene cannot currently be produced in industrially relevant quantities. What is the point of spending money to develop applications that cannot be manufactured? Indeed, how can one even perform R&D on actual industrial applications without significant quantities of available material? So on one hand, until plentiful, high quality, low cost graphene is readily available, industrial applications will not be developed, and on the other, without industrial applications requiring large quantities of graphene, there is no market to produce the material on a large scale. It's a classic chicken-or-egg dilemma.

Let's take a mathematical look at the analyst projections mentioned above. In my conversations with industrial representatives, their potential interest in graphene is very keen, but they are fully aware that the current pricing of the material, even if it were readily available, is far too high to warrant significant industrial investment. Simply put, the current price range of high quality graphene, anywhere from $10 to $1,500/g is far too high to justify using the material, in spite of any enhancements in the physical properties of their end-products. It is just too expensive to use graphene as an additive in a typical industrial process. The price point that industry can support, depending on application, is typically less than $10/g; below this level, industrial interest in R&D and potential adoption becomes a real possibility. At $10,000,000,000/yr, the annual production of graphene needs to be 1,000,000,000 grams, assuming a price point of $10/g. This means that 1,000 metric tons of graphene must be produced each year, or very roughly, about 100 tons per month. Compare this figure with the actual current worldwide production of high quality graphene in the amount of a few kilograms per day. The discrepancy is staggering and becomes even more overwhelming as the price is driven down well below $10/g.

The chicken-or-egg dilemma can only be resolved in one direction: it is imperative that the production of graphene be increased first. Industrial-scale applications simply cannot be developed without industrial-scale quantities of graphene. The challenge for our generation of scientists and engineers is to develop industrial processes to make literally tons of material cheaply enough to drive the price point downward while maintaining the quality of the final product. This is where Celtig enters the picture.

At Celtig, we are living up to this new challenge by developing, designing, and implementing new technology to drive the production of graphene up and the cost of manufacturing it down, all the while maintaining strict quality control. Our patent-pending technology, developed in-house by company principals, now allows for an exponential growth in the worldwide

production capability of graphene, and at the same time drives the price point well below $10/g for most grades of material. Our current production capacity of 1,000 kg/month is readily expandable once the market increases, yet in the meantime, we are finally able to achieve truly industrial-scale graphene production that will allow entrepreneurial manufacturers access to sufficient quantities of this fascinating material for internal research and development of actual consumer-oriented applications. Our primary goal at Celtig is to facilitate this revolutionary transformation: taking graphene from the academic benchtop of the research scientist and delivering it to the daily life of the general public.

Celtig has teamed up with a growing number of industrial manufacturers to explore potential applications of graphene directly in actual manufacturing processes. These initial efforts will have a great impact on the future of graphene. Successful trials will result in a rapid expansion of the graphene industry, leading to launches of new or significantly enhanced products. Failures will provide setbacks, but hopefully not roadblocks. Regardless, the only way to determine the potential usefulness of this new material, graphene, is actually to use it on an industrial scale and just see what happens. At Celtig, we are very excited about these new possibilities.

We welcome your interest in working with Celtig either at the industrial or the academic scale. If you have a potential collaboration to suggest, we would love to hear from you to discuss possibilities. Please contact us via phone or email using the information provided on our webpage. We look forward to hearing from you.

Sincerely,

Brian Edwards, *CEO*
CELTIG LLC