# MIT Roll to roll process for making continuous graphene

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You'll already know that the Massachusetts Institute of Technology (MIT) houses some of the best scientists and engineers in the world. They have also spent the last few years developing a continuous manufacturing process for making graphene. Let's take a look at what they have been doing…

## *The continuous graphene process*

MIT first announced their work making graphene by a continuous process back in 2015. It is a measure of just how difficult this is in practise that over three years later the team is still developing the process. They are making good progress though.

MIT are using the chemical vapour deposition process. This brings hot hydrogen and methane close to the surface of solid copper. Graphene forms on this surface and when the copper is covered the reaction stops. This is called a self-limiting reaction and results in a one-atom layer thick of graphene on the surface of the metal. We described this process at InvestorIntel over two years ago. It was capable of making graphene at 25 mm per minute.

Now the process has been developed further. The speed has been doubled to 50mm per minute without losing quality. This seems to be due to a lot of effort dedicated to controlling the growing conditions inside the furnace.

It looks like a lot of hard work has gone into the process

optimisation of this method. The process can now produce consistent quality graphene on copper on a strip ten mm wide and ten metres long. This takes about four hours to produce. About 41mm per minute.

## *The quality of the graphene*

The team describe their graphene as high quality. What they do not say is that is perfect graphene, so we can conclude from this that the graphene sheet is polycrystalline and it probably contains gaps and defects.

Dear reader you will recall from my previous articles that quality means different things to different people. It depends on the application to which you put the product.

The quality of the graphene this process produces is probably not the continuous domain (single crystal) graphene the team in China produced last year. So it probably cannot be used for applications where high strength and conductivity are required. However this quality of graphene will be appropriate for filtering applications. This is why the team have cleverly used a polymer called PES to act as a support for the graphene and create a filter membrane.

They cast a solution of PES polymer on the graphene surface and allowed the PES to harden as the solvent carrier evaporated. Then they etched away the copper foil with Ammonium Persulphate (APS-100). This left the graphene stuck on the PES film.

## *Making the membrane*

This process created graphene with occasional large tears and holes. You can imagine that these are not wanted for a filter membrane, much smaller holes are better. The big holes were sealed with an organosilicon compound. Then the smaller holes

were created by exposing the graphene / PES material to an oxygen plasma making the membrane.

## *In summary*

MIT have developed a continuous process for making graphene. They are to be congratulated on their work. However on closer inspection this process produces graphene with tears and holes that have to be sealed. There is post processing needed and it seems this part of the process is not continuous at the moment.

This is good progress, and shows just how hard it is to make graphene as large scale sheets.  The teams working on this process in China, Norway and Korea will understand the difficulties too.  I hope you all keep persevering. This requires near-heroic effort and you have my admiration.