Structural Reliability
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Lecture –05
Introduction (Part - 05)

In our next example on how structural performance affects system safety and reliability we turn to a very familiar device the mobile phone.

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What you see on your screen is actually a museum piece the world's first commercial cellular phone introduced in 1983-84 it cost 4000 American dollars at that time and it was nicknamed the Brick phone the Motorola Dinotalk 8000x it was 10 inches tall plus the antenna and weighed 800 grams. So, the nickname was obvious the battery offered about 30 minutes of talk time and it took 10 hours to recharge.

We are not going to talk about how cell phones revolutionize the way we communicate and do business in the four decades since then but we will focus on how with increasing popularity and usage and capabilities there was a need to have better batteries with better performance. Those early Ni-Cad batteries were replaced first by nickel metal hydride batteries that came after them and the lithium-ion batteries that we use today.

And for good reasons these lithium-ion batteries have no memory effect they have high energy density they can withstand many charging cycles they are also the power source of choice for today's electric vehicles.

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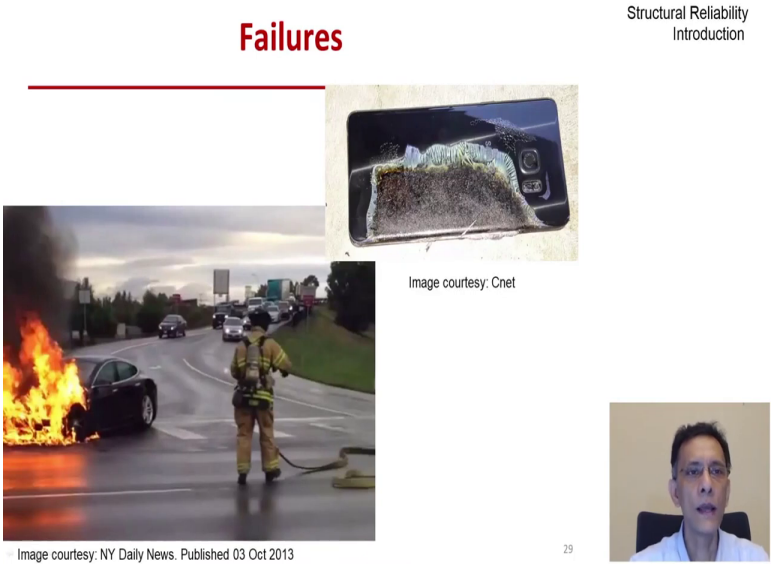

But whether they are in cars smart phones or airplanes these lithium-ion batteries can catch fire. The rate of catching fire is rare about one in 12 million by one estimate but you know 6 to eight billion cells are now produced each year by another estimate. So, in absolute numbers these are not negligible.

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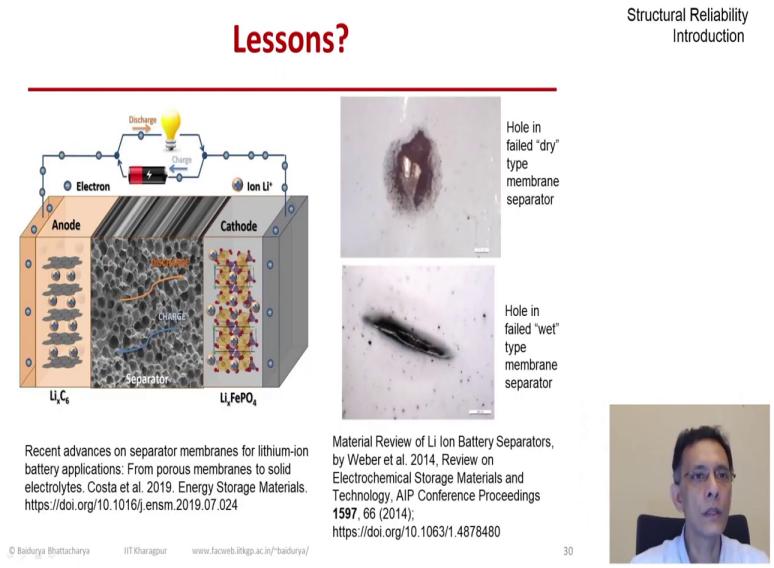

So, what you see on the left of your screen is a schematic of the lithium ion battery. Basically it is a series of anodes and cathodes separated by separators that must allow the electrolyte solution with lithium ions to pass. The separator material is typically some porous membrane made of some polymer matrix soaked with an electrolyte solution basically lithium-salt dispersed in an organic solvent.

Such as the polyolefin membranes produced by the so-called wet or dry processes that you see on the right in two failed samples. Now parameters that affect the separator performance are permeability the porosity the electrolyte absorption and retention and of course chemical thermal and mechanical stability. These separators are subject to pressure thermal cycling high temperatures as part of normal operation and then impact load like in EVS and conductive debris as you see in these failed samples.

So, these can cause the separators to fail to fail mechanically and which may lead to short-circuit fires and possible explosion. Therefore separators have a strong impact on cell performance life cost as well as safety and reliability. Unfortunately in the battery manufacturing community strength of lithium-ion cells against mechanical loading has not been a design consideration in a systematic manner.

So, better separated design is an active area of research including replacing them with solid electrolytes but many challenges are there. So, whatever it will be it is clear that the structural performance and structure reliability of these materials will play a central role.